ANNALS
OF
The Entomological Society of America

Volume XXVI JUNE, 1933 No. 2

ENTOMOLOGICAL CENTENARIES

HERBERT OSBORN.

The fact that some European Entomological Societies are celebrating centenary anniversaries calls attention to the long activity of some of these organizations and while none of our American societies can boast so long a record it is true that entomological activity with us began a good century ago. Recalling such names as Say, Harris, Melsheimer, Peck and others will carry us back to that period.

The recent anniversaries of the Société Entomologique de France and the Entomological Society of London were events of more than passing interest to entomologists the world over and they certainly deserve attention from New World Entomologists and especially the members of the Entomological Society of America. We may feel quite sure that the activities and successes of these and other European societies were potent factors in the establishment of similar societies in America.

The celebration of the French society was staged with the Fifth International Congress in Paris, the ceremonies taking place on the Saturday, July 19th, preceding the regular sessions of the Congress. These were held in the auditorium of the Jardin des Plantes in the presence of a distinguished assembly including the President and other officers of the Republic and many representatives of foreign societies, among them some of our members and official delegates from our society.

Appropriate addresses[1] were delivered by Doctor R. Jeannel, the President of the society; Doctor E. L. Bouvier, Honorary President, and M. Justin Godart, who represented the Ministers

[1]Published in N° du Centenaire, Tome XXXVII, Bulletin Soc. Ent. de France, 1933.

of Education and Agriculture. Doctor A. Lameere spoke for the foreign universities and societies, M. le Pr. Caullery for the French Institutes and Universities and M. H. Gadeau Kerville for French societies. Messages of felicitation were presented from a large number of institutions and societies from all parts of the world. On Sunday morning following, a most interesting pilgrimage was made to the tomb of Latreille, one of the founders of the society. A memorial wreath was placed upon the tomb and appropriate remarks were made by Bouvier and Jeannel.

The celebration of the London Society Anniversary which occurred on May 2nd, 1933, has taken form in an historical volume,[2] which brings together a most interesting assemblage of records concerning the origin and activities of the Society. There is an introductory chapter by Professor E. B. Poulton, President, 1903–4, 1925–6, 1933, which sums up in a very entertaining manner the struggles and successes of the growing society and gives charming tributes to a number of the early members.

The general record of activities have been brought together under the able editorship of Doctor Neave and there are short biographies of Children, Darwin, Curtis, McLachlan, Hope, Kirby, Spence, Stephens, Westwood, Wollaston, Stainton, Dunning, Bates, Sharp, Wallace, Walsingham, Verrall, Godman, Salvin, Champion and Miss Ormerod.

Illustrations include as frontispiece a portrait of Professor Poulton in a characteristic pose, pictures of the original meeting place, the Thatched House Tavern and its meeting room, and the present permanent home of the Society at 41 Queens Gate, the new meeting rooms and portraits of Kirby and Westwood. In addition there is a record of benefactions and a list of the officers and fellows.

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[2]See this issue, page 261.

THE PHOTORECEPTIVE ORGANS OF A FLESH FLY LARVA, LUCILIA SERICATA (MEIGEN): AN EXPERIMENTAL AND ANATOMICAL STUDY.

JOE KOEBELE ELLSWORTH,[1]
University of California, Berkeley, California.

Flesh fly larvae, although devoid of eyes in the commonly accepted sense, are extremely reactive to light, being sensitive to one hundred and seventy-six hundred thousandths of a candle meter (.00176 C. M.) as shown by Herms (1911). The same author demonstrated that "the functional photoreceptive organs are highly concentrated and equally distributed bilaterally in the immediate region of the oral pole." He employed a light pencil with which he explored the entire body of the larva in order to locate the sensitive region or regions. Only one region was found where the light caused the larva to turn, and that was at the extreme oral pole.

Loeb (1890) pointed out that "only the rays of light striking the oral pole of the larva are effective in orientation." This conclusion, however, was reached crudely by the following method: the larvae were placed on a board, which was thrust forward from a dark area into sunlight in such a manner that the oral pole of the larva was first to be subjected to sunlight. This caused the insect to withdraw its head and take up a position parallel with the rays. Lowne (1890) was able to discover "a pair of eye-like organs at the extremity of each maxilla." These he compares with the simple eyes of the leech, but adds that, in the case of the larva, the organs are devoid of pigment.

Publications by Weismann (1864) and Lowne (1890–93) on the comparative anatomy and morphology of the "blow fly;" Pouchet (1872), Holmes (1905), Herms (1911), Mast (1906), Lubbock (1888), on the reactions of insects to light; Packard (1903), Snodgrass (1925–26), Imms (1931) on the morphology of insect sense organs, have aided the author in this investigation.

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[1]Contribution from the Division of Entomology and Parasitology, University of California, Berkeley, California.

GENERAL DESCRIPTION OF LARVA.

The larva of *Lucilia sericata* (Meigen), like other "maggots," has a soft, pliable skin, which is whitish in color, sometimes thick and leather-like. It is cylindrical, wedge-shaped, gradually increasing in diameter toward the posterior end, which is obliquely truncated. Like all "maggots," it is devoid of legs; locomotion being effected by means of pseudopods and the mandibular hooks. The pseudopods, in the form of swellings of the body wall, possess minute hooked spinules.

Banks (1912) describes the larva as follows:

"Body rather stout, not slender in front. Head very distinctly bilobed, mandibles two, well separated. Anterior spiracle with about eight lobes. Surface of the body mostly smooth; . . . . Last segments short, stigmal field occupying most of the tip, slightly depressed, upper lip with three sharp tubercles on each side; the intermediate one hardly smaller than the others; lower lip with two large, sharp tubercles on each side, and a medium pair more remote from the margin. Anal area rather sunken, with a small rounded tubercle at each corner. Stigmal plates about one-half their diameter apart, each with three straight slits, directed somewhat toward each other, but also downward."

"These stigmata," according to MacGregor (1914), "in the fully formed larvae occur as two fan-shaped stigmal plates, from 0.44 mm. to 0.46 mm. in breadth, and lying from 0.40 mm. to 0.48 mm. apart, when the distance measured is from the center of one 'button' to the center of the other. The 'button' in this genus is well developed, and the 'ring' is delicate and sharply delimited from the rest of the plate. The slits are three in number, and are crossed by from 11–14 separate relatively broad bars, which run from the extreme edge of the one side of the slit to the extreme edge of the other. Between these bars the gaps are large, fairly equal in size, and clearly outlined; their longitudinal measurement being usually greater than the breadth of the bars."

The integument of the mature "green bottle" larva is thick and leathery. Its cuticular portion consists of two distinct parts—the epiostracum and the endostracum. The epiostracum forms a continuous layer over the whole external surface and is inflected into the mouth, anus, and spiracles. It forms the solid spines on the anterior portion of the segments, and the muscles are inserted into it by means of fibers. It is because of the impermeability of this leather-like integument that microsectioning *in toto*, is practically impossible.

EXPERIMENTAL.

Technique.—A light pencil method of demonstrating the photoreceptive function of the so-called cuticular organs has been used by Harper (1905) on the earthworm, *Perichaeta bermudensis* (Beddard) and by Herms (1911) on the larvae of flesh flies, *Lucilia caesar* Linn. and *Calliphora vomitoria* Linn.

Harper (1905) illuminated portions of the earthworm with a 32-candle power incandescent lamp, controlled by screens. Herms (1911) used a pencil of light apparatus consisting of a chamber containing a 77.4 cp. Nernst lamp, diaphragms, and a reading glass. The Nernst lamp at a distance of 50 cm. gave a light pencil of one to two mm. in width at the point of experimentation, which varied with the path of the traveling larva. By using a smaller stage and suspending it, the light pencil could be played on the larva at will.

The light pencil used by the author differs from the two above methods in construction, but is the same in principle. The apparatus consists of a three-celled "Eveready" flashlight, to which is attached a dark cylindrical tube, containing the condensing lens of a projecting lantern. The lens combination concentrates a large amount of light at the focal point.

With this set-up a pencil of light of about 2 mm. in diameter was obtained. The apparatus is light and easy to handle, which makes it rather simple to play a pencil of light of constant size and intensity on a definite part of a crawling insect, irrespective of its path.

Light Tests.—All parts of the body of a larva of *Lucilia sericata* (Meigen) were carefully explored with a light pencil similar in principle to that of Herms (1911). When the light reached the tip of the oral end (Plate I), the larva responded immediately, turning away from the source of the light. By throwing the light pencil continuously on either side of this region, the larva could be forced to crawl in circles, either clockwise or counter-clockwise. When all portions of the oral region were equally illuminated, the larva crawled in a direct line. Herms (1911), in another test, covered the region of the oral pole with a mixture of lard and lampblack. On illuminating that portion, there was failure to produce any turning until the substance had been rubbed off in crawling.

To further illustrate the sensitiveness of this region to light,

the following tests were made. A larva was placed under a high-powered binocular microscope and the tips of the maxillary lobes were severed. It was believed that the portion removed would not hinder the larva except in its reactions to light. This "blind" larva was placed with a normal larva upon a table illuminated on one side by a light. The normal larva immediately proceeded to travel directly away from the light, while the "blind" larva did not move. After prodding with a pencil, the "blind" larva began to crawl. The direction in which it traveled had no relation to the source of the light. Two other similarly treated larvae were placed upon the table and made to crawl in the direction of the light. The "blind" larva continued toward the light, while the normal larva immediately stopped, oriented itself, and traveled in the opposite direction.

When the light pencil was employed on the "blind" larva, it failed to produce any effect upon its orientation. The length of the body of the larva was explored in order to ascertain if there were any secondary photoreceptive organs. However, no such organs were found.

The above experiments were repeated several times using a new set of larvae, one "blind" and one normal, for each test.

Conclusion.—It may be concluded from the experiment with the larvae of *Lucilia sericata* (Meigen) that the rays of light striking the oral pole are effective in orientation, and that the removal of the tips of the maxillary lobes causes a definite inability on the part of the larvae to orient themselves.

HISTOLOGICAL.

Material.—The larvae of the "green bottle" fly, *Lucilia sericata* (Meigen), used as material for the preparation of this paper were reared from eggs laid on fish or meat by gravid females, which were kept in rearing cages in the laboratory. The eggs were transferred to a sterile medium prepared for this purpose. The larvae were not used for the various experiments until they had reached full growth.

Gross Anatomy of Cephalic Region.—For the study of the gross anatomy (Plate I), larvae were anaesthetized and then observed under the binocular microscope. Generally, the head is considered as the first obvious segment; the second, third, and fourth segments belong to the thorax; and the remaining eight comprise the abdomen. Although we speak of the head as the

first segment, it represents in reality the three post-oral metameres of the embryo. It is believed that the procephalon, or the first of these segments, invaginates and disappears within the mouth. It is not distinguishable externally in the mature larva.

The second of these segments enlarges, projects beyond the procephalon and forms the greater part of the head of the larva. This segment, the maxillae (mx), consists of proximal and distal portions. The former is subcylindrical and exhibits a very remarkable half-disc on its ventral and outer surface, the stomal disc (sd), and in the stomal disc the orifice of a sac in which the mandibular hooks (mh) lie when retracted. The stomal disc, a nearly semicircular surface, is grooved by a number of radiating dichotomously dividing channels. The mouth (mo) presents a triangular orifice between the prestomal sclerites (ps). The base of the triangle is formed by the labium (la), or the lower lip, which exhibits a medium and two lateral lobes, almost covering the mouth orifice when the larva is not feeding. The distal portion is subhemispherical and when viewed from above appears bilobed. Each of these maxillary lobes (ml), bears a pair of minute, cylindrical tubercles or papillae, each of which represents one of the sensory or photoreceptive organs (po).

The third segment is usually invaginated within the prothoracic segment, so that it cannot be seen except when the larva is forcibly extended. Newport (1836) correctly described this segment (ns), hence it is referred to as Newport's segment.

Following these three cephalic segments, there are three thoracic and nine abdominal segments, a total of fifteen, as contrasted with the obvious twelve segments noted above.

Technique.—In preparing material for the study of the more minute structural details that can only be satisfactorily studied in serial sections, the paraffin method was employed, although with much difficulty. The difficulties have been due principally to the impermeability of the integument and to the fact that paraffin does not readily adhere to it and to the extreme friability of the tissue after embedding.

At first the larvae were fixed *in toto*, in Bouin's Picro-Formol solution (Guyer, 1930). After fixation the tissue was washed, dehydrated, cleared in xylol, and embedded in paraffin in the usual manner. This method proved defective. Before the tissue had been dehydrated it began to turn brown and to

disintegrate, probably due to the impermeability of the integument.

Zenker's fixing fluid (Guyer, 1930) was used instead of Bouin's, but the same discoloration occurred.

When this method of attack proved unsuccessful, the author began searching for other methods that might serve the purpose, with the result that the following method described by Bowman and Linch (1931) was adopted for studies *in toto:*

"Drop tissue in some ten per cent formalin solution and heat to boiling. Transfer it to acetone and leave it in this liquid for one hour, during which time the acetone should be poured off and renewed with fresh material two or three times. The dish should be covered and put in the paraffin oven, as diffusion takes place more rapidly at the higher temperature. Remove the tissue from the acetone and drop it into a container of melted paraffin. Leave this in the oven for one hour." Embed in paraffin in the usual manner (Guyer, 1930).

This method proved satisfactory in that it made possible the location of the principal organs and their relative positions as well as enabling the sectioning of the larva, *in toto.* However, the formalin had a tendency to distort and destroy the structure of the cells, making it impossible to obtain stained sections perfect in detail.

Finally, the first method described above, namely, Bouin's Picro-Formol fixative with the usual paraffin embedding, was resorted to with the following difference: the insect, instead of being fixed and embedded *in toto*, was fixed and then cut into small pieces. These small pieces (i. e., the head and thorax) were washed, dehydrated, cleared, and embedded in the following manner:

Inject into the body cavity with a hypodermic needle a solution of: Picric Acid, 15 cc.; Formalin, 5 cc.; Acetic Acid, 1 cc. When injecting the solution, exert pressure sufficient to extend the larva. Leave for two to four hours. Cut the larva into small segments, then drop the pieces back into the fixative and let stand over night. Wash in a 1 per cent solution of Sodium Bicarbonate until the yellow disappears (this removes the excess Picric Acid); follow this by washing a short time in cool running water. Dehydrate, 30, 50, 70, 80, 95 and two changes of 100 per cent alcohol. Place in xylol until clear (approx. one to two hours). Place the tissue in a solution of one-half paraffin and one-half xylol—in the paraffin oven.

Place in 42°–44° paraffin for one hour, 47°–49° for one hour, 53°–55° for one hour. Embed in 53°–55° paraffin. Section, mount, and stain in the manner described below.

This latter method gave very good results for small portions of the insect, viz., the head region showing the maxillary lobes, their structure, and relative position in the head. By using a batch of larvae of the same age, taking them through the above process the author was able to obtain fairly complete stained sections of the larvae. However, the most important part was orienting the tissue and getting sections through the maxillary lobes.

The slides were stained mainly with Delafield's Hematoxylin and the counter stain of Eosin or Orange G in the usual manner (Guyer, 1930). Delafield's stain was made heavy and the counter stain light, so as to give a distinct contrast. A few sections were taken through an aqueous solution of Methylene Blue before counterstaining. This gave a bluish tinge to the nervous tissue and aided in differentiation.

Photoreceptive Organs.—There are two pairs of photoreceptive organs contained within the bilobed maxillae of the larva of *Lucilia sericata* (Meigen), one pair in each lobe (Text Fig. 1). As stated above, these organs when extended and viewed externally appear as minute papillae on the apices of the maxillary lobes.

Each photoreceptive organ resembles very closely the ocellus or simple eye of other insects. The organ consists of a biconvex lens (ls), a preretinal membrane (vb) (the vitrous body of Snodgrass), a fasciculus of fibrils (fb), retinal cells (ret), a nerve bundle (nb), and is apparently devoid of pigmented cells.[2]

Each flask-shaped organ is surrounded by a delicate reticular membrane (rm) and is capable of extension and retraction. Within this organ is a compact mass of elongated bipolar cells with basal nuclei, which may be considered as retinal cells (ret). The distal prolongations of these cells form a compact fasciculus (fas) of fibrils (fb), which terminate at the thin transparent membrane (vb), apparently comparable to the vitrous body of the adult ocellus as described by Snodgrass (1925). The membrane lies directly beneath the lens. There is a larger number of fibrils near the outer edge of the compact fasciculus than in the center.

[2]Pigmented cells which are not light receptive, but those used for the protection from overstimulation by light.

There is a biconvex cuticular lens (ls), which according to Snodgrass (1925) is probably formed by the secretions of the corneagenous cells of the outer layer of the integument. Covering the lens is a very thin membrane, the cuticula (ct), which is the continuation of the epiostracum of the integument and is continuous over the entire external surface of the larva.

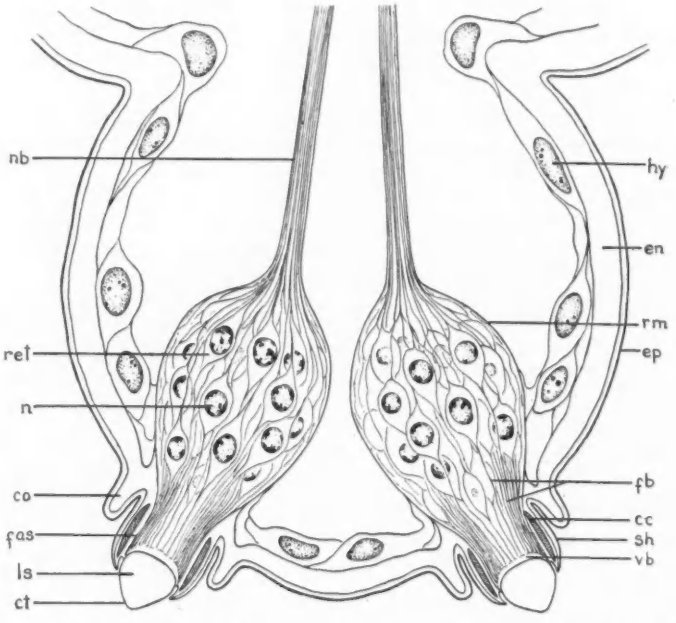


FIG. 1. Showing a pair of photoreceptive organs contained within the bilobed maxillae of the larva of *Lucilia sericata* (Meigen). The drawing is diagrammatic to the extent that it is bilaterally symmetrical. 1900×.

The lens, as the organ is extended or retracted, moves outward or inward within its sheath (sh). The outer layer of the sheath is the epiostracum (ep). In the inner layer, or the endostracum (en), is embedded a chitinous cylinder (cc) of a distinctly different structure than that of the integument proper, being denser and taking stains more readily. Surrounding the sheath is a thick cuticular ring or collar (co). When the organ is retracted this collar forms a protecting cover.

The proximal processes of the retinal cells combine to form

a nerve bundle (nb). The nerve bundles from each of the four photoreceptive organs come together, those of each pair joining first, and farther on, uniting to form the optic nerve. The optic nerve was traced to the precephalic frontal ganglia and thence to the optic ganglia and into the brain proper.

Conclusions.—(1) The larvae of the "green bottle" fly, *Lucilia sericata* (Meigen), possess two pairs of highly specialized photoreceptive organs contained within the bilobed maxillae, which are capable of extension and retraction.

(2) Each photoreceptive organ consists of a biconvex lens, a preretinal membrane, a fasciculus of fibrils, retinal cells, a nerve bundle, and is apparently devoid of pigment cells.

DISCUSSION.

The sense organs of insects present a great variety of forms, most of which are still incompletely understood, in spite of the fact that many investigators have given attention to these organs. Sense organs are generally distinguished by the nature of the stimulus to which they react.

That the sense organs described in this paper are photoreceptive is conclusively proved by the use of a pencil of light which when projected upon the oral end of the larva is effective in orientation. This was also proved by the fact that the removal of the tips of the maxillae caused a definite inability on the part of the larvae to orient themselves. This light pencil method of demonstrating the photoreceptive function of the so-called buried cuticular photoreceptive organs has been used by Harper (1905) on the earthworm, *Perichaeta bermudensis* (Beddard) and by Herms (1911) on the larvae of flesh flies, *Lucilia caesar* Linn. and *Calliphora vomitoria* Linn.

Harper (1905) states, "The earthworm avoiding reaction in strong light is of the nature of a definite reflex which causes it to turn directly away from the stimulus, if the whole body is in the light; or to retreat, if only the anterior end is stimulated; or to go forward if the posterior end alone is stimulated." Herms (1911) demonstrated that in the "green bottle" fly larvae "the functional photoreceptive organs are highly concentrated and equally distributed bilaterally in the immediate region of the oral pole." This highly localized position of these organs in the flesh fly larvae is in contrast with the more widely distributed sensitive buried cuticular cells of the earthworm as noted by Harper.

In the latter, protection against overstimulation is accomplished by the telescopic contraction of the segments. Harper (1905) concluded that, "The body is less sensitive to light when contracted than when extended, owing to the fact that when extended the sensitive elements are spread out over a greater surface and become more susceptible." This reaction is accomplished in the fly larva through the retraction of the entire photoreceptive organ, which is further protected by the infolding of the chitinous collar.

The dorsal ocellus of adult insects is stationary and possesses pigmented cells which migrate forward to form a protection to the retinal cells when the organ is subjected to a strong light. As far as the author was able to ascertain, there were no pigment cells in the photoreceptive organs of the larva of the "green bottle" fly. Protection from strong light as explained above, is accomplished in a more specialized manner than in the case of either the earthworm or the ocellar organs of the adult insect.

Snodgrass (1925) states that, "The word 'eye' is used in a general sense for any specific organ that is sensitive to light falling upon it and capable of transmitting the resulting stimulus to the central nervous system. An eye is primarily a light-perceiving organ, or a photoreceptor, and it is not to be assumed that all eyes are capable of registering impressions of form, color, or motion in external objects. The effect of the light stimulus on the organism must vary with the structural development of the eye and of the visual centers of the nervous system." In general, ocelli (the euthyscopic eyes) are divided into two classes: dorsal or primitive ocelli and lateral or adaptive ocelli. The dorsal ocelli are characteristic of nymphs and adults and occur in all the chief orders of Pterygote insects, but they ure not present in the larvae. The fact that the lens is strongly aiconvex indicates that the visual powers of the larvae are bmited to the perception of very near objects, if any, and are lised to distinguish between light and darkness.

Lateral ocelli, according to Imms (1931) present no general uniformity of structure. They are the functional visual organs of the insect larva and are antecedent to the future compound eyes of the imago. The lateral ocelli of insects usually consist of an invagination of the hypodermis beneath a lenticular thickening of the cuticula, with the sense cells differentiated at the inner end of the cup and a crystalline body formed by a secretion in the distal part beneath the lens.

These eyes occur in a group on each side of the larval head, frequently at the place where the compound eye is to be developed in the pupa, but it is believed that the larval eyes degenerate without taking any part in the formation of the compound eye, and there appears to be no ground for the belief that the larval ocelli are ommatidia of the adult eye.

The ocelli of the "green bottle" fly larva, *Lucilia sericata* (Meigen), closely resemble the frontal ocelli of adult insects, with the exception that they are devoid of pigment. Certainly they have no relation to the lateral eyes of other insect larvae and, therefore, the author regards them either as primary frontal ocelli occurring in the larval stage which have migrated to the side of the head or as an independent development in the larvae of a more highly specialized organ which is capable of extension and retraction.

GENERAL CONCLUSIONS.

1. The larvae of the "green bottle" fly, *Lucilia sericata* (Meigen) are extremely reactive to light, responding negatively.
2. The larvae possess two pairs of highly specialized photoreceptive organs contained within the bilobed maxillae, which are capable of extension and retraction.
3. The functional larval photoreceptive organs are highly concentrated and situated bilaterally in the immediate region of the oral pole.
4. The removal of the tips of the maxillary lobes causes a definite inability on the part of the larvae to orient themselves.
5. The rays from a light pencil striking the oral pole are effective in orientation.
6. Protection against overstimulation by light is accomplished through the retraction of the entire photoreceptive organ, which is further protected by the infolding of the chitinous collar.
7. Each photoreceptive organ consists of a biconvex lens, a preretinal membrane, a fasciculus of fibrils, retinal cells, and a nerve bundle, and is apparently devoid of pigment cells.

ACKNOWLEDGMENTS.

The author wishes to acknowledge his indebtedness to Prof. W. B. Herms, under whose direction this investigation was carried on; to Dr. W. M. Hoskins and Dr. R. Craig for helpful suggestions; to Miss Dorothy G. Harris for the illustra-

tions which accompany this paper; and also to Mr. A. E. Michelbacher for a constant supply of fly larvae. Others to whom the author is indebted are: Miss Florence M. Frost, G. H. True, Jr., and Rodney S. Ellsworth. To all these and to others not mentioned the author expresses his thanks.

LITERATURE CITED.

Banks, Nathan. 1912. The structure of certain Dipterous larvae with particular reference to those in human foods. U. S. D. A. Tech. Series No. 22: 1–44.

Bowman and **Linch.** 1931. A Short Method for the Preparation of Animal Tissue for Staining. Science, Vol. 74, No. 1922, October 30, 1931.

Guyer, M. F. 1930. Animal Micrology. Univ. of Chicago Press. 302 pp.

Harper, E. H. 1905. Reactions to light and mechanical stimuli in the earthworm, *Perichaeta bermudensis* (Beddard). Biol. Bul., 10 (1): 17–34.

Herms, W. B. 1911. The Photic Reactions of Sarcophagid Flies. Jour. Exp. Zool., 10 (2): 167–226.

Holmes, S. J. 1905. The selection of random movement as a factor in phototaxis. Jour. Comp. Neur. Psych., 15 (2): 98–112.

Imms, A. D. 1931. Recent advances in Entomology. Blackston's, Philadelphia, Penn.: 1–364.

Loeb, J. 1890. Der Heliotropismus der Tierre und seine Uebereinstimmung mit dem Heliotropismus der Pflanzen. Wurzburg, 8 vol., 188 pp.

Lowne, B. T. 1890–2. The anatomy, physiology, morphology and development of the blow fly (*Calliphora erythrocephala*). London, 1: 1–350.

1893–95. The anatomy, physiology, morphology and development of the blow fly (*Calliphora erythrocephala*). London, 2: 351–778.

Lubbock, John. 1888. On the senses, instincts, and intelligence of animals, with special reference to insects. London, 292 pp.

MacGregor, M. E. 1914. The posterior stigmata of Dipterous larvae. Parasitology, vii (2): 181.

Mast, S. O. 1906. Light reactions in lower organisms. Jour. Exp. Zool. 3 (3), 359–399.

Newport, G. 1836–9. Article "Insecta"—Todds' Cyclopaedia of Anatomy and Physiology. London.

Packard, A. T. 1903. A text-book of Entomology. Macmillan Co., London, pp. 249–264.

Pouchet, G. 1872. De l'influence de la lumiére sur les larves de diptera privers d'organes exterieurs de la vision. Rev. et Mag. de Zool. ser. 2, tom. 23.

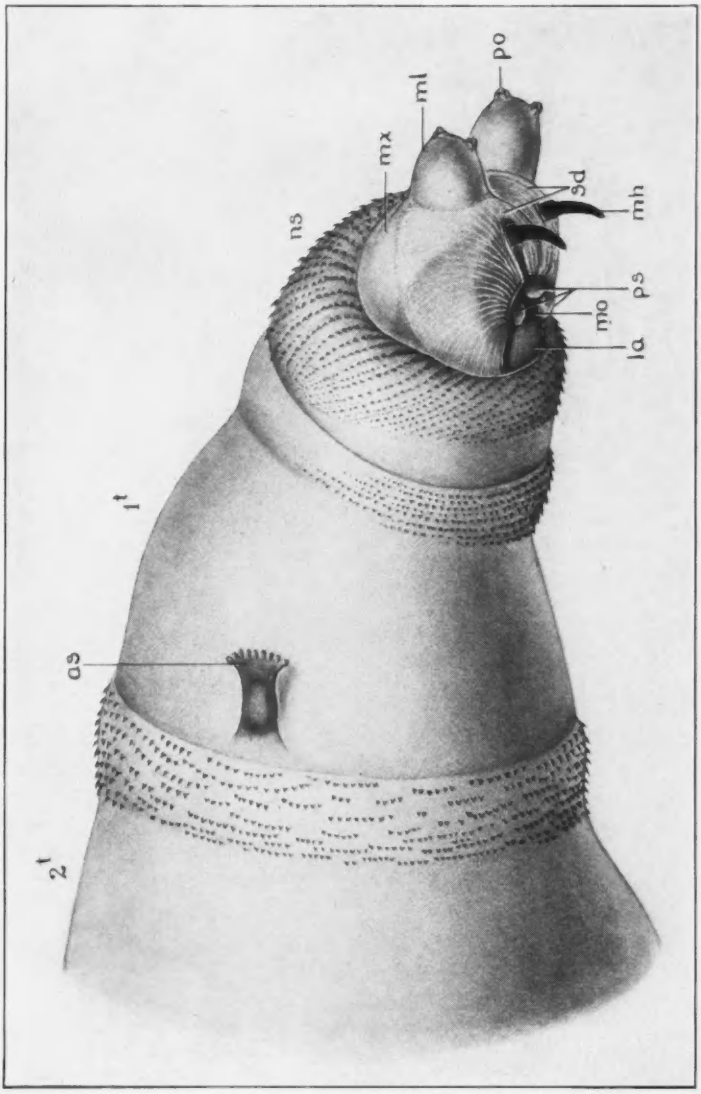
Snodgrass, R. E. 1925. Anatomy and physiology of the Honeybee. McGraw-Hill Book Co.: 224–246.

1926. The morphology of the insect sense organs and the sensory nervous system. Smithsonian Misc. Col., 77 (8): 1–80.

Weismann, A. 1864. Die nachembryonale Entwickelung der Musciden nach Boebachtungen an *Musca vomitoria* und *Sarcophaga cornaris*. Zeitschr. f. wiss. Zool., Bd. 14, Heft. 3: 187–336.

EXPLANATION OF PLATE.

The anterior portion of the flesh fly larva, *Lucilia sericata* (Meigen), showing the segmentation of the cephalic region and the relative position of the photoreceptive organs. 1t, 2t, first and second thoracic segments; ns, Newport's segment (3rd cephalic); mx, maxillae (2nd cephalic); as, anterior spiracle; sd, stomal disc; mh, mandibular hooks; mo, mouth; ps, prestomal sclerites; la, labium; ml, maxillary lobes; po, photoreceptive organs.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ADDITIONAL NOTES ON THE STREPSIPTERON EOXENOS LABOULBENEI PEYERIMHOFF.

H. L. Parker and H. D. Smith,
Bureau of Entomology.

Sixty years ago (1870) Alex. Laboulbène for the first time found this remarkable insect in a stump along the Nice-Cannes road, in France. This find consisted of five brownish flattened puparium-like shells, each bearing three pairs of legs terminating in long tarsal claws. Dr. Laboulbène was unable to assign them to any definite place among the known insects because of their strange nature, and because of peculiar "nymphal" remains found inside these shells. He first thought they were dipterous puparia, but in a later article describing them (3) he concluded that the shells were old larval skins of a coleopterous insect closely allied to the Meloidae or Rhipiphoridae. He made excellent drawings of this larval skin as well as of the "nymphal" remains found inside them. These remains were in reality those of the adult female *Eoxenos*, which transforms within the old larval skin.

In 1919 P. de Peyerimhoff (5) reported that he had been finding the same or a similar insect under stones in Algeria at rare intervals for nigh on to twenty years. M. de Peyerimhoff evidently went through the same mental process as did Dr. Laboulbène, but was unable further to clarify the mystery until he eventually procured the first-stage larvae. This fortunate discovery immediately cleared the identity in a general way and M. de Peyerimhoff erected a new genus, *Eoxenos* (Order Strepsiptera), and described the species as new, basing the description on the adult female and the first-stage larva.

The present writers found this insect for the first time on April 6, 1930, while searching under stones in an extremely arid thyme field near Tourves, Var, France. Three isolated larval skins were found, two empty and one containing the adult female. They were lying free under stones, among debris or on the dirt, but not in a cell or gallery of any sort. No host remains were near the specimens. During the next two years many other specimens were found and will be considered further on in this paper in a summary manner.

After several weeks of speculation, during which the writers went through the identical stages of mental gymnastics that Dr. Laboulbène and M. de Peyerimhoff had gone, and after having come to the same conclusions as the former did, Dr. G. Salt, of the Imperial Institute, Farnham Royal, from a verbal description, recognized our insect as similar to *E. laboulbenei*, and M. Lesne, of the Paris Museum, pointed out to us the article by Peyerimhoff.

It is a curious fact that though this insect was described in 1874 it is not mentioned in entomological textbooks, though practically all of those now in general use have been compiled since that time. Inspired partly by the desire to break this—probably unintentional—conspiracy of silence and by the extraordinary peculiarity of this insect, the writers have determined to bring it from its hiding places under the limestone rocks of Provence and the dark junipers of the Bouira Sahary, and, eventually, to expose its mysteries to all who tinker with insects.

Descriptions of Known Stages of *Eoxenos laboulbenei* Peyerimhoff.

EGG.

The eggs (within female), (Pl. I, Fig. 1) are 0.07 mm. in diameter, globular in form, and have a thin transparent shell. They have a clear central portion and an outer belt of irregular hexagonal cells containing solid matter extending in a central plane around the egg at the periphery, which represents the developing embryo (April). Later, just before hatching, the young larva can be seen curled up in the egg, the last two pairs of abdominal segments and the caudal setae being folded ventrally underneath the body (Pl. I, Fig. 2).

LARVA.

First-stage larva (*triungulinid*), (Pl. I, Figs. 3, 4).—Length, 0.19 mm.; width (thorax) 0.07 mm.; color light brown, body composed of head and 13 segments, segments telescoping, sclerotized dorsally, two pairs of long caudal setae on last segment.

The head is in the form of a rather thick half disc with a thin apical and lateral border. It bears in the lateral angles two eyes of a primitive type apparently composed of five transparent ocelli underneath which is a mass of dark brown material. Dorsally the surface of the head is smooth and bears no spines or setae; ventrally near the apex is the mouth opening. On each side of the mouth opening is a short spine-like seta which probably represents the mandible and below is a long pair of spine-like setae reaching almost to the second thoracic segment, probably representing the whole maxillae or a portion of them.

The chitinous bands composing the segments cover the dorsal and lateral portions of the body, while the ventral area is composed of a lighter and softer skin.

There are three pairs of legs, each composed of four joints. The coxae (apparently) are rather large and flat and do not articulate, but are simply attached to the skin. They bear spines on the anterior edges, those of the first two pairs being stronger than those of the last pair; the femora are rather conical in shape and bear spines on their inner edges, those of the last pair being longer; the tibiae are simple, those of the hind legs bearing several spine-like setae; the tarsi of the prothorax and mesothorax are small, rounded, leaf-like spatulae, those of the metathorax are unguliform.

The body segments are approximately equal in length except the twelfth, which is elongate and somewhat conical in shape and bears at its apex two rather stout, short, pointed projections; the thirteenth segment is extremely small and is carried within the ventral apical fossa of the twelfth.

The body setae are as follows: dorsally, a pair on each thoracic and two pairs on the ninth abdominal segments; subdorsally, a lateral pair on all thoracic and first nine abdominal segments; ventrally, there is one pair somewhat widely separated, on each of the second to eighth abdominal segments and two pairs on the ninth; more laterally, on the edge of the chitinous bands there is a single pair on each of abdominal segments one to nine. The last segment bears two pairs of long caudal setae, the central pair being stouter and two-thirds as long as the body.

Internal Anatomy.—The alimentary canal consists of a straight tube extending from the mouth posteriorly through the thorax, where it enlarges to fill the abdomen. The midgut seems to terminate blindly as a large oval sac in the anterior portion of the ninth abdominal segment. Laterally can be seen two short tubes extending forward from the region of the tenth abdominal segment or thereabouts for a short distance; these tubes apparently attach to an irregular mass of material which extends forward to the thorax, filling the space on each side of the midgut. These organs are probably the reproductive cells and with the stomach are the most prominent structures visible internally. There are no signs of the genital pore on the abdomen. There seem to be no tracheae or spiracles. Other tiny cells scattered in irregular groups about the body probably represent fat cells.

The ninth abdominal segment has many fibres within it, most of which are probably muscles extending to the tenth sclerite, to which the caudal setae are attached.

Last-Stage Larva (described from skins).—Length, 6.0 mm.; color brown; in general it is "tortoise-shaped" (though somewhat more elongate), flat below, convex above. Female roughly oval; male narrower and with sides more parallel.

Female Larva (Pl. II, Figs. 11, 12).—Head, thorax, and abdomen well differentiated. The thorax is not separated from abdomen, but there is a slight constriction between the second and third thoracic

segments. The head (Pl. I, Fig. 5) is (roughly) obtusely triangular and rather flat; it has a simple mouth opening; a pair of simple and seemingly fixed mandibles (*md*) is situated upon rounded cuticular tubercles a short distance laterally from the mouth; there is a pair of two-jointed maxillae or maxillary (?) palpi (Pl. I, Fig. 5, *mxp*, Text Fig. 1, D) and dorsally there is a pair of apparently two-jointed antennae (*a*). The head seems to be joined to and articulate upon the thorax by a cuticular membrane. Normally it is considerably depressed so that the mandibles and palpi appear to be hidden within the preoral cavity. The thoracic segments are distinct and each bears a pair of

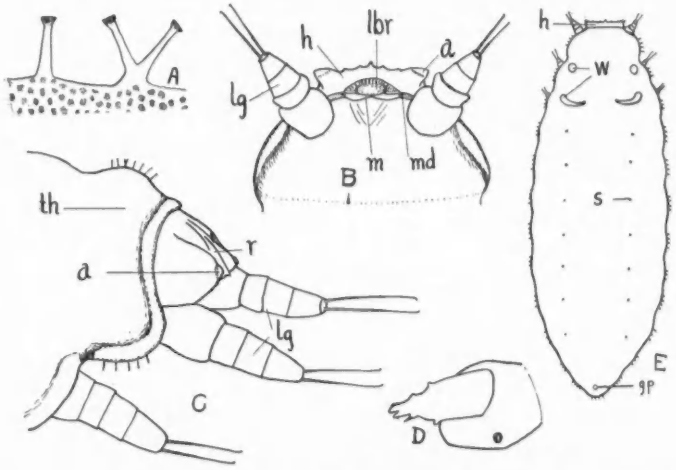

FIG. 1. *Eoxenos laboulbenei* Pey. (Strepsiptera), showing outlines of parts of last-stage larva. A, fragment of skin with a bifurcate and a simple tegumentary spine; B, head and first thoracic segment of male larva; *a*, antenna; *lbr*, labrum; *h*, head; *lg*, leg; *m*, preoral cavity; *md*, probably mandible (or maxillary palpi) indistinctly visible within preoral cavity; C, side view of head and thorax of male larva; *th*, thorax; *a*, antenna; *r*, rostrum; *lg*, leg; D, maxillary palpus (?) of female larva; E, outline of male larva, from above; *h*, head; W, wing pads; *s*, spiracle.

simple four-jointed legs, the last joint of which bears two long simple spines slightly hooked at the apex. Dorsally there is a pair of small round plates on the first thoracic segment. The abdomen is composed of ten distinct segments; ventrally there is a small anal opening or mark on the extremity of the tenth segment, while on the posterior border of the seventh segment is a round plate with a slightly thickened center representing the future genital pore; dorsally there are seven pairs of simple spiracles (Pl. I, Fig. 6) on the first seven abdominal segments. Short bits of tracheae can be seen still attached to these spiracles, and from the anus can be seen a short narrow piece of tube (the hind

intestine) extending inwardly to the seventh abdominal segment. A distinct lateral suture separates the dorsum from the venter and these two equal walls may be easily and completely separated by simply running a needle around the suture. The body bears on each segment more or less near its middle, both dorsally and ventrally, an irregular series of short simple or branched spikes; the skin under high magnification appears rough and is covered by small, dark, pigmented spots (Text Fig. 1, A).

The Male Larva (Text Fig. 1, E, B, C) is similar to the female except that it is smaller, narrower, and does not have the broad oval outlines of the female. There is no genital plate or spot on the seventh abdominal segment, but on the ninth is a larger round imprint bearing near its posterior border three small, dark spots. Grouped around the periphery of this disc are what appear to be pieces of tracheae. There are distinct wing pads on the second and third thoracic segments (*W*); these are absent in the female larva. In most cases the male larval head and first thoracic segment are absent.

ADULT.

Adult Female (Pl. II, Figs. 10, 13).—Length, 4 mm.; shape broadly oval; color light brown; composed of head, thorax, and ten abdominal segments; wingless, three pairs of legs, trochanters absent, tarsi four-jointed, body tegument soft but tough and leathery, legs, head, and antennae brownish.

The head (Pl. II, Fig. 9) is more heavily sclerotized than the body, somewhat flattened above and below, composed of a brownish sclerotic cranium (in form conical, truncate) bearing dorsoanteriorly a pair of simple five-jointed antennae; laterally are the primitive compound eyes, ocelli absent, frons, clypeus, and labium not differentiated; ventrally, near the anterior margin, there is a simple mouth opening and a pair of simple mandibles articulating in the subgenae, they are more or less comma-shaped seen from the front, but seen from the side they are slightly spatulate. Above the mouth opening is a small area (*lbr*) which may represent the labrum.

Somewhat below the mandibles and slightly laterally there is a pair of simple two-jointed maxillary (?) palpi (*mxp*). The antennae and maxillary palpi bear a number of small hairs while the former has, in addition, a great number of circular "sensory" rings on the last two segments. There are no tentorium or other supporting skeletal structures, save a slight articulating ramus for the mandible at the angle of the subgenal and postgenal plicae (or ridges).

The thoracic segments are similar in appearance; the first is narrowest and bears a pair of small brownish dorsal plates (Pl. II, Fig. 10) which were indicated also in the larva; they are simple and broadly attached to the head and the abdomen; there are no appendages except the legs (Pl. I, Fig. 7), and these are composed of coxa, femur, tibia, and tarsus, the last being four-jointed on all legs; the two claws of the tarsi are stout and simple with a basal portion slightly enlarged to form a sort of pad; there are a few short setae and a number of circular organs

in certain places on the legs near the joints similar to those seen on the antennae; there is a small triangular sclerite immediately above and outside of the coxal attachment.

The abdominal segments are of about equal length except the tenth, which is small and almost circular; the seventh bears ventrally near the posterior border a transverse slit-like genital opening, the borders of which are somewhat thickened, while the tenth bears a small round opening which may be called the anus, though no faecal remains have ever been found in female larval shells; dorsally, there are seven pairs of spiracles (Pl. II, Fig. 14) on the first seven abdominal segments. The tegument is much folded near the intersegmental lines, is covered with tiny tubercles, and bears, near the middle of each segment, a series of simple setae.

From examination of three specimens stained *in toto* in carmine, the writers have been able to make fragmentary observations on the internal anatomy.

The alimentary canal consists of a rather narrow, straight tube leading from the mouth through the thorax, a slightly enlarged mid-intestine, and a short, straight, tube-like hind-intestine. The tracheal system is composed of seven pairs of spiracles located dorsally on the first seven abdominal segments, two longitudinal trunks, spiracular branches, and a ramified segmental branch in each abdominal segment. Below the spiracle is a thick-walled chamber (Pl. II, Fig. 14, *ch*) into which the spiracular branch (*trw*) opens; this chamber is probably the combined spiracular atrium and closing apparatus. The muscular system seems to be simple and not extensively developed. Apparently there are groups of muscles in the head controlling the mandibles, in the legs, and in the antennae. Otherwise the tegumentary muscles consist principally of the following groups: ventrally two sublateral longitudinal bands consisting of about a dozen thin strands extending the length of the abdomen and thorax. In each of the seventh and eighth abdominal segments there are a few thin strands which are attached on the anterior border of the segment near the median line and which extend obliquely to the posterior border of the segment where they are attached laterad of the longitudinal band. In addition to the above there is a fan-shaped transverse group on the floor of each thoracic segment arising near the median line and extending laterally to a point near the coxal attachments. Dorsally there are two longitudinal bands on each side, one just dorsad of the spiracular line and another near the median line. In each of the first eight abdominal segments there is a group of muscles composed of 8–10 fibres attached near the middle of the segment between the two longitudinal bands and extending ventrally and slightly laterally to a point on the ventral floor of the same segment just laterad of the ventral longitudinal band (i. e., to a point slightly below the lateral line).

The body muscles of this insect appear normal in striations and have many tiny spherical nuclei distributed throughout them. They are remarkable for their extreme fragility and in this respect they are comparable to the body muscles of the larvae of certain groups of

parasitic Hymenoptera such as the Chalcididae which, like the female of *Eoxenos*, lead a sedentary life. If the female is touched no movement takes place and she appears to be dead; when the abdominal walls are pushed out of their regular form the muscles will react to cause it to assume its regular shape. Otherwise the female never moves. Only when stimulated mechanically by cutting or contact with strong fluids some movement such as slow contortions has been noted.

The hypodermal cells are extremely small and very irregularly distributed over the skin. In many places the latter is entirely bare.

The blood cells can be seen in patches and clots scattered about inside the body. They are larger than the hypodermal cells and vary in size and shape considerably.

On the floor of the abdominal segments extending transversely can be seen a group of spherical cells regular in size with tiny, darkly stained (carmine) nuclei. These cells probably represent the oenocytes. In many cases the nuclei are simple, but often they are split into three or four smaller spherical parts.

The writers have been unable as yet to see any details of the nervous system in their preparations.

The only parts of the reproductive system which we have been able to observe are the genital opening and the tube or vagina. The former is, as mentioned above, a transverse slit-like opening on the posterior border of the seventh abdominal segment. It has two rather thick lips, anterior and posterior, which remain more or less closed. The vagina is a rather prominent tube extending forward from the genital opening into the fifth abdominal segment, where it flattens out and terminates abruptly. The anterior termination is open at all events at hatching time so that it is possible to pass from the body cavity proper to the exterior via this tube. This end of the vagina is not attached to anything, but apparently "floats loose" in the body cavity. The remaining space in the body cavity seems to be entirely filled with eggs, from the head, in which a half dozen eggs are lodged, to the tips of the abdomen. So far as the writers have been able to observe there is no connection between the individual eggs or between these and the genital tube; they lie rather closely packed but without order and loose in the body cavity.

Adult Male.—The male adult has never been seen but when a male nymphal skin is removed from the larval shell and spread it furnishes certain clues to the probable appearance of this sex. This skin is, unlike that of the female, usually whole, and is covered with fine tubercles. It shows further that the male abdomen is prominent, at least as long (and probably longer) than the thorax and head, and bears seven pairs of spiracles. The antennae are three-branched (i. e., the nymphal case of the antenna is three-branched) and are rather short and stout; the legs are approximately of the same size as those of the female, but the last pair is considerably removed from the first two pairs. The anterior wings are represented by a slender membrane; the hind wings are probably present but folded within the body of the pupal skin. The supposition that the male has normal Strepsiptera

wings is further strengthened by the shape and size of the wing-pads on the thorax of the male larva (Text Fig. 1, E, *W*). The abdomen is nine-segmented and is divided into a terminal and a ventral lobe, the latter being considerably larger.

The writers believe that the male will be found to possess functioning mandibles probably similar to those of the female. This supposition is based on the fact that a single male larval skin among the 21 found possessed a head, and the probable explanation of this condition is as follows: As before stated, the male usually issues by pushing off the head and first thoracic segment of the larval skin, but in this case a different procedure was adopted. The male must have chewed its way out through the floor of the thorax, leaving its own nymphal skin in the tip of the larval abdomen. The study of the size, shape, and position of the opening, the number, direction, and inclination of the thrusts which pierced the hole, and other considerations,[1] lead to this conclusion.

Thus it would seem that the male is a normal strepsipteron possessing characters not incompatible with those of the family Xenidae.

HABITAT, BIOLOGY, AND SEASONAL HISTORY.

The locality where this insect was found by the writers is in the Aix-Brignoles Valley, about two kilometers from Tourves, on the road leading to Roquebroussanne. The immediate spot is on an extremely arid knoll covered with thyme; the whole region is of calcareous composition and this field is covered with disintegrating limestone rock. Most of the specimens were found around the edges of a big pile of small stones and under isolated stones surrounding this pile, all within a radius of about 15 yards. One specimen only was found about a hundred yards away from this rock pile.

In all 42 larval skins have been found since April, 1930. Of these, 21 were males, 19 females, and 2 fragmentary and undeterminable. Six of the skins bore live females and four bore remains of dead females within them. All others were empty. Some of the empty skins of both sexes were apparently of recent date. This condition for the male larval skins could easily be explained by their normal emergence, but the case of the empty female larval skins required further probing.

At first it was supposed that the female issued from the larval skin probably after the hatching of the young. This is apparently not the case, judging from the female remains found in four of these skins. In all four cases the remains

[1]This specimen, with a female skin and an adult female and triungulinids, has been deposited in the U. S. National Museum.

of the female showed that hatching had taken place and no emergence of the mother female. The most probable explanation is that predators such as ants had devoured the contents of those female larval skins which were found completely deprived of adult remains.

The writers have observed the pupal membrane around the female within the old larval skin. It is usually broken into tiny fragments and parts of it are sometimes found blocking the opening left by the falling off of the larval head. Among the shells of the male larvae some contained the thin membrane of the male pupa left there by the emerging adult, others were entirely empty. This condition might be explained by supposing that the male when issuing sometimes left its pupal skin within the larval shell and sometimes dragged this skin out as it emerged.

Hatching and Comportment of Triungulinids.—In June, 1931, it was seen that the body contents of a gravid female collected in April were gradually turning darker; and as a previous year's hatching had taken place in early July, the writers kept this female in a small glass vial under constant observation.

On the afternoon of July 3 the vial was picked up for examination and to the observer's satisfaction several tiny brown triungulinids were seen walking around inside. Apparently the shock stimulated the process of hatching for within less than sixty seconds several thousand triungulinids had issued and were crawling and jumping wildly about in the tube. The shell of the last-stage larva enclosing the female and the sides of the tube were literally covered with these young insects and the writers were so taken by surprise that it was some time before they could collect wits enough to observe how the process of emerging was being accomplished. In fact it was not until most of the young had issued and the female was removed from the larval skin that the process, then considerably slowed down, was observed accurately.

Briefly the hatching process is as follows: the young larva breaks out of the egg by straightening its body, in this process pushing with the anal setae; it then wends its way among the masses of eggs and egg-shells which fill the body to the anterior or loose end of the genital tube, through which it passes. Emerging through the genital opening of this tube the young larva crawls around on the body of the female, then works its

way forward and out through the neck of the old larval shell. It then raises its abdomen, folds the two pairs of setae underneath the body, and jumps away.

For some minutes the process of jumping was a mystery to the observers and was not sufficiently clear until a larva in the process of emerging was observed to have its last segment and anal setae caught and wedged between the lips of the genital opening. Observed in profile this larva could be seen to bend its body forward until it lay flat upon that of the mother, then with a sudden jerk it would click its body into the straight position, thus giving the key to the movement. It was next observed that in free specimens before jumping the larva would raise the abdomen and fold the setae underneath the body.

The majority of the triungulinids seemed to find their way out without difficulty, though how they come to find the distal end of the genital tube is a mystery. At the end of the hatching period a few stragglers were observed to be wandering around among the mass of eggshells. Some were seen to be near the genital opening but outside the tube (i. e., still within the body cavity), where they would wander for some time, eventually finding their way to the distal end and to the outside. Finally, as will be seen, all but two had emerged and these never issued. (In the case of the 1930 female, all but two issued successfully.)

The body of the female is not disturbed; her internal organs are not attacked and no larvae issue, so far as could be observed, elsewhere than through the genital opening.

In five of the cases where a live female was found in the old larval skin, the latter was headless; in the sixth case the head was present but somewhat detached from the thorax, thus leaving an opening through which the young could emerge.[2]

The triungulinids were observed to be positively phototropic and advantage was taken of this condition to manipulate them into several glass vials.

At this moment several possible hosts were exposed to the young larvae. Cocoons of a species of ***Limnerium***, a parasite of ***Pyrausta nubilalis*** Hbn., in which small slits had been cut, thus permitting the young Strepsiptera to have access to the pupae and prepupae of the Limnerium contained therein, were supplied; cocoons of ants containing larvae and pupae, and

[2]This head, incidentally, was the only female larval head found among the 42 specimens.

larvae and pupae of the wasp *Polistes gallicus* L., which had been in readiness, were also given.

The triungulinids paid no attention to these things and eventually the exposed pupae and larvae produced adults or died with no signs of *Eoxenos* parasitism.

On the following day, July 4, at 11 a. m., many triungulinids were still alive in the tube with the female and a few stragglers were still coming out of the genital aperture. On July 5 there were still three moving within the body cavity of the female, all others being dead. The next day the body of the female was opened, exposing two unhatched eggs. In this process the female demonstrated that she was alive by several slow contortions of the body.

Biological Probabilities.—Speculation upon the biology of this insect, while more or less useless, is nevertheless absorbing. If it proves to be parasitic, as we may expect, what can be the host? Under and around the stones in the field where it is found are any number of species representing many orders. Ants, caterpillars, roaches, grasshoppers, bugs, and beetle larvae of many sorts are extremely abundant. In no case have apparent host remains been discovered near the last larval skin.

How does the triungulinid attain its host? It is not unlikely that it wanders around or jumps about until it brings itself into contact with a host. Many triungulinids of other species find their way to the host by clutching on to a moving form, such as that of a bee or wasp, to be transported to a nest where host larvae or pupae are available. Just how they cling on is not quite clear, as they seem to have no mandibles or other organs fitted for grasping unless it be the legs. These appendages are used for crawling and in immobilized larvae observed were constantly being waved about from one side to the other, so it would seem unlikely, though not impossible, that they would be used for clinging to a moving host.

How could this larva without mandibles penetrate a host or pierce a hole in order to procure its nourishment, in case it were an external parasite? This question, however, is applicable to many other species which are without mandibles and which nevertheless penetrate their host successfully.

Can it be that this species is free-living during its entire life? The only basis of supposing it to be parasitic is that other Strepsiptera are parasitic. It is quite probable that the last-

stage larva wanders around after emerging from the host, judging from the appearance of the exact spot in which it is found, as there are no signs of its having passed any considerable time in this one place, and it is not impossible that it passes its whole larval life in a free condition.

It is evident that, from the data presented with the larval descriptions, the two sexes are present. How, if at all, does mating take place? The female is formed and remains within the last-stage larval skin. This skin possesses, as stated, a small round plate or genital mark. In the center of this plate is what appears to the writers to be a tiny hole or pore, though whether or not it be an actual aperture has never been determined. It looks like a hole, but even so it may be closed over with a lighter colored membrane. It is too small to admit the point of a fine camel's hair.

When the female is observed within the old larval shell, it can be seen that the genital aperture of the former is more or less juxtaposed against the genital "pore" of the latter and it may, as the female was being formed, have been perfectly placed so as to permit mating. In this case mating must have taken place through the genital "pore" of the old larval skin with the male outside and the female inside this skin. In one case a mass of hardened brownish material was observed within the female larval shell over and about the genital pore. This material was carefully removed *in toto* and observed under the high power. It bore opposite the genital pore a small but distinct hole as if it had been pierced at this point or else had hardened in this manner, leaving the copulatory tract open for mating.

Other hypotheses to consider are: (1) that mating takes place between larval forms, which would seem improbable, more particularly for the last larval stages, as the male larva of this stage has no copulatory appendages; (2) that mating takes place by the oral aperture; (3) that this animal reproduces both sexes parthenogenetically. It seems to the writers that the last hypothesis is the most tenable, but this opinion is based solely on the apparent obstacles to mating mentioned above.

Seasonal History.—The seasonal activities as indicated by the data on hand are as follows:

In late summer, probably about the first of September, the final larval stages of both sexes are formed. These larvae

probably crawl around some and find their way under stones, etc. Soon thereafter the nymphal period is accomplished within these larval skins. The adult male issues at once in the manner already described, i. e., by pushing off the head and thorax of the old larval skin or chewing its way out by the ventral floor of the thorax, and either sets about its task of fertilizing the females or else goes its useless but pleasant way to the near-by thyme fields. The female, after shedding her nymphal skin, enters into a quiescent stage lasting until the following July, during which time the eggs are brought to maturity. Females found on October 8 were full of developing eggs, but in an earlier stage of development than those found in April. In late May, however, the embryos begin to take on their final aspect and by June they are turning dark. At the end of this month they are fully formed and ready to issue during the first days of July.

SYSTEMATIC CONSIDERATIONS.

The systematic position of this species, according to M. de Peyerimhoff, is in the family Xenidae of the Strepsiptera. That author placed the species in this family from a comparison of the larval triungulinid characters with those of *Xenos vesparum* Rossi. Another author, Dr. Ogloblin (4), has described and figured the first-stage larva of *Pseudoxenos shaumii* Sanders, belonging to the same family, and it is quite similar to that of *E. laboulbenei*. The most striking characters of these triungulinids are the tarsal pulvilli on the first two pairs of legs and the claws on the last pair, and the four caudal setae.

The writers pointed out that there are small but striking differences between the triungulinid found by them and that figured by M. de Peyerimhoff. The latter is shown with two caudal setae instead of four. It is hardly possible that this excellent observer would have overlooked the second pair had they been present. This author, however, described the triungulinid from a dead and dried specimen and it is possible that one pair of setae may have been broken off from the specimen which he described, in which case it would have been impossible to notice such a condition. Another point in which our specimens differ from M. de Peyerimhoff's figure is the length of the setae representing the maxillary palpi, and the

absence of the seta in the anterior angle of the eye in our specimens. Nevertheless, the above differences are considered too meager to permit of the erection of a new species, and until such time as more data can be had on the biology and missing stages, it is best to unite all information under the name of *E. laboulbenei.*

While the discovery of the triungulinid by M. de Peyerimhoff leaves little doubt that this animal belongs to the Strepsiptera, the writers may point out to corroborate this identification that there is a great similarity between the head sclerites, etc., of the last-stage larva and that of other strepsipterous larvae, i. e., of the head of females figured by Pierce (6) et al.

Of what importance is this insect in classification? Naturally the value of the anatomy and biology of this curious species can not be fully estimated on the present fragmentary knowledge. The male must be described, the biology and larval stages studied. Nevertheless it is interesting to note that this species presents the most perfect "insectiform" female known among the Strepsiptera and that it resembles in some respects the female of a rhipiphorid, *Rhipidius pectinicornis* Thunb. (1, 2, 7), which is wingless and has rudimentary eyes. The principal characters of the female are coleopteriform and in the writer's opinions they exhibit, if not a natural affiliation, most certainly a striking apparent relation to the order Coleoptera.

The most fascinating thing about this insect, and that which remains to be discovered, is its manner of larval life.[3] What are the curious and possibly revealing stages through which it passes before reaching the strange form we know? What gymnastics of transportation, what morphological changes, does it undergo before it finally comes to rest under a protecting stone? What is the mysterious future before the tiny planidium, as it makes its way to the outside world, clambers over the shell of its dying parent, and with one jump leaps off to its destiny?

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[3]Dr. G. Salt is of the opinion that some light might be shed on the systematic affinities of this insect by a comparison with *Hornia minutipennis* Riley, a parasitic meloid beetle, the female of which is extremely curious.

LITERATURE CITED.

(1) **Bétis, L.** 1912. Faune entomologique armoricaine. Rhipiphorides (Coléoptères). Bul. Soc. Scient. Méd. Ouest, Rennes 21: 33–40, illus.
(2) **Chobaut, A.** 1891. Description d'une nouveau espèce de Ripidius avec quelques remarques sur ce genre. Le Coléopteriste, 1891: 235–237, illus.
(3) **Laboulbène, A.** 1874. Note sur une nymphe d'insecte Coléoptère incluse dans la peau durcie et pupiforme de la larve, trouvée à Cannes au mois de Mars, 1870. Ann. Soc. Ent. de France 4 (5): 44–48, illus.
(4) **Ogloblin, A.** 1925. New and little known Strepsiptera from Poland. Polskie Pismo Entomologiczne 3: 113–122, illus.
(5) **Peyerimhoff, P. de.** 1919. Un nouveau type d'insectes Strepsiptères. Bul. Soc. Ent. de France, 1919: 162–173, illus.
(6) **Pierce, W. D.** 1911. The comparative morphology of the order Strepsiptera together with records and descriptions of insects. Proc. U. S. Nat. Mus. 54: 391–501, illus.
(7) **Thunberg, C. P.** 1806. Tvenne nya Insect-slägten, Ptyocerus och Ripidius. Vetensk. Acd. Nya Handl. 27:5.

EXPLANATION OF PLATES.

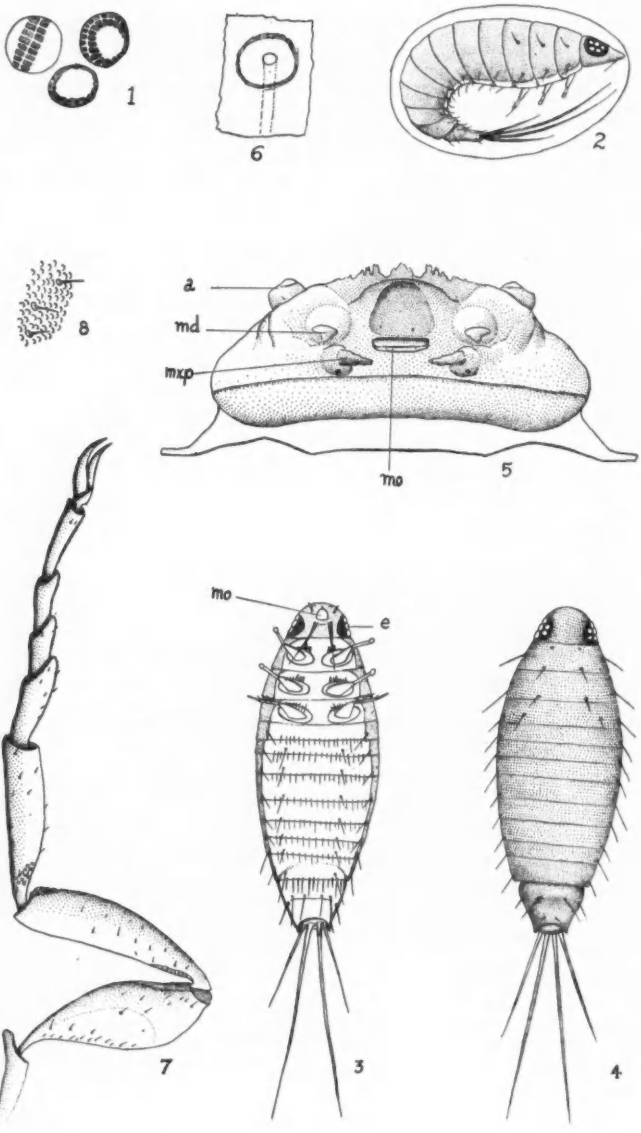
Eoxenos laboulbenei.

PLATE I.

Fig. 1. Eggs within female (April).
Fig. 2. Triungulinid just before hatching.
Fig. 3. Triungulinid, ventral view; *mo*, mouth; *e*, eye.
Fig. 4. Triungulinid, dorsal view.
Fig. 5. Head of fully grown female larva; *a*, antenna; *md*, mandible; *mxp*, (?) maxillary palpus; *mo*, mouth.
Fig. 6. Spiracle of fully grown larva with piece of trachea attached.
Fig. 7. Leg of adult female.
Fig. 8. Piece of skin of adult female showing tubercles and spines.

PLATE II.

Fig. 9. Head of adult female; *md*, mandible; *lbr*, labrum; *mxp*, (?) maxillary palpus; *mo*, mouth.
Fig. 10. Adult female.
Fig. 11. Last stage larva of female, dorsal view.
Fig. 12. Last stage larva of female, ventral view.
Fig. 13. Adult female head outline, side view.
Fig. 14. Spiracle of adult female; *spo*, spiracular opening; *ch*, stigmatic chamber; *chl*, lumen of chamber; *trl*, tracheal opening into chamber; *trw*, tracheal wall.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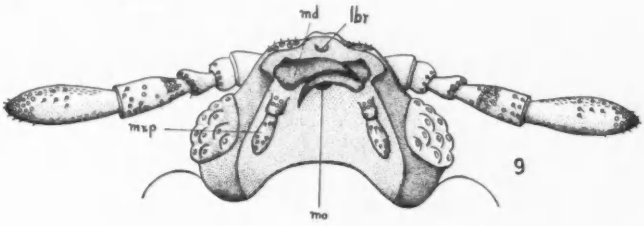

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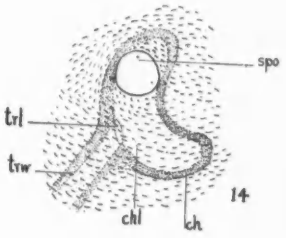

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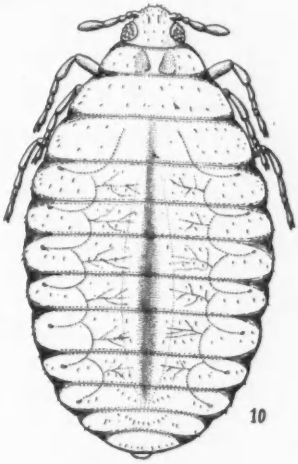

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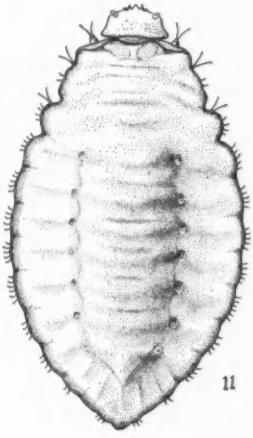

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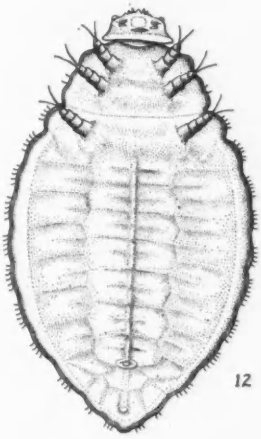

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COLLECTING GRYLLOBLATTA CAMPODEIFORMIS VAR. OCCIDENTALIS SYL.[1]

R. H. BEAMER.[2]

The Grylloblattidae, a small family comprised of only two genera, possibly but one, apparently belong to the order Notoptera. The two species and one variety in the genus Grylloblatta occur in North America, the other genus, Callois-iana, with one species and one variety, is native of Japan. All of the above species are represented by very few specimens and many of these are nymphs. The fact that one species and one variety have been described from nymphs only, together with the unusual scientific interest which this family of insects has aroused due to their primitive structure and peculiar life habits, seems just cause to set out the facts pertaining to the collecting of six adults and numerous nymphs of this species, on Mt. Baker, Wash., in 1931.

Professor F. Silvestri, published, in the Transactions of the American Entomological Society, September, 1931, a description of *Grylloblatta campodeiformis* var. *occidentalis* from 22 nymphs which he had taken on Mt. Baker, July 21 and 22, 1930. He did not collect his material under snow. In fact he seems to make a point of the fact that snow was not present and in most cases was some distance away.

Mt. Hood, Oregon, was the scene of our first efforts. Having arrived at Cloud Cap Inn by mid-forenoon on the morning of July 18, the party took the trail leading to Eliot Glacier. The countless tons of rock which make up the lateral and terminal moraines of this interesting glacier were somewhat stupefying to one hunting for an insect an inch long. Great numbers of rocks were turned along the steep slopes of one of the moraines. Several members of the party ventured into the bed of the stream leading from under the frozen debris which was the actual end of the glacier. On went the searchers two or three miles up the glacier, turning stones in every conceivable position—beside the snow, under it, on top of it,

[1]Material determined by A. N. Caudell, of the Bureau of Entomology.
[2]Department of Entomology, University of Kansas.

until fingers were raw and backs aching. Although a number of Coleoptera and Hemiptera were taken under stones on the ice, no Grylloblatta were found. This failure but served to increase the desire of each member of the party to be the first to place one of these rare creatures in the cyanide jar.

Many inquiries as to roads to snow fields and general type of habitat surrounding them led the party to select the Mt. Baker National Forest for its next trial. We arrived during the morning of July 29, and were immediately lured to some snow banks on the north slope of Table Mountain which were but a few minutes walk from camp. These snow fields we found were melting rapidly during the sunny part of the day and thus considerable water was encountered along their lower edges. The bank where our first find was made was deeper than most of the others and was hollowed out underneath so one could walk or crawl beneath it from one end to the other. Water was dripping and even running from hundreds of places beneath this drift. It was here underneath tons of snow and ice that Mr. L. D. Anderson, turning stones, found a small white creature which he could not place and which he was afraid to hope might be one of the long sought treasures. He called to the author and we both agreed, although neither of us had ever seen a specimen of Grylloblatta, that this must surely be a baby specimen of the famous family. This tiny nymph, about 5 mm. long, was found almost directly beneath a small stream of water coming from a point of the snow above our heads. We therefore began a minute search of this spot and almost immediately found other specimens. Within 10 or 15 minutes the two of us had taken about two dozen of the tiny creatures. Then Mr. Anderson moved a few feet away and turning a stone about four inches square, came upon an adult Grylloblatta. It was a nice large brown female of the species *Grylloblatta campodeiformis* var. *occidentalis* Sylvestri. The good news soon spread to the other members of the party and the hunt was on in earnest. Satisfaction was to be somewhat slow in coming, however. Specimens we could find, but almost in every case they were tiny white nymphs. The party of six working two days could find but six adults. My youngest son, Jack, eleven years old, was the champion with three to his credit.

Most of the specimens were secured, not under the bank of snow where the first was taken, but about the lower edges of other temporary patches of snow which were spread out over rocky north slopes. The method yielding the most specimens was to break away the snow from the edge of the bank and turn stones immediately beneath it. Warm stones were barren as were dry ones. The temperature must not be far from the freezing point and the soil must be moist. Green material was noticed in the abdomen of some of the nymphs, supporting the facts as related by Norma Ford for caged material. One of the adults collected by my son bit him on the finger.

ADULTS.

The adult males and females agree in essentials with *G. campestris* Walk. They do have a greater number of antennal segments as Sylvestri predicts they should.

The female has 32 antennal segments and the male 36.

EXPLANATION OF PLATE.

FIG. 1. Searching for Grylloblatta by breaking down snow banks in order to turn stones under them.

FIG. 2. Under the snow bank where the first adult specimen of *Grylloblatta campodeiformis* var. *occidentalis* Syl. was taken.

Collecting Grylloblatta
R. H. Beamer

PLATE I.

OBSERVATIONS ON THE FLIGHT AND LENGTH OF LIFE OF DRONE BEES.

D. E. Howell and R. L. Usinger,[1]
University of California.

The flight activities of drone bees seem to have been much neglected in literature which has rightly placed more emphasis upon the workers and queens. It has, however, been known that drones favor the warmer hours of the day. In an effort to determine at what time during the day drones actually fly as well as how many flights they make per day and the duration of their flights, the authors have observed various hives over a period of days of varying weather conditions. Two other problems, the age at which drones take their first flight and how long drones live, were also studied.

The following notes and observations were made at the Apiary of the University of California at Davis, California, during the month of May, 1932. The problem was suggested and supervised by Dr. J. E. Eckert, for whose patience and guidance the authors are exceedingly grateful.

METHODS.

In determining at what time during the day drones fly, a gross count of all drones entering and leaving the hive was made. Hand tallies were used for this purpose and temperature and humidity data were noted as possible explanations.

For the other problems, however, it was necessary to mark drones in specific color patterns which consisted of combinations of red and yellow paint. The paint consisted of a mixture of alcohol, shellac, and pigment. The thorax was used most frequently for this marking, although paint on the abdomen was used with no apparent detrimental effect.[2]

[1]The arrangement of the author's names is an alphabetical one and does not indicate seniority.

[2]This paint is used regularly at the Apiary of the University of California at Davis in marking all queen bees and has had no detrimental effect on their length of life or egg laying.

ACTIONS OF A DRONE IN LEAVING AND RETURNING TO THE HIVE.

From the time drones first peer out of the opening of the hive and until they actually take off from the bottom board they go through an elaborate, if somewhat hasty, preening. Special attention seems to be paid to the antennae which are very carefully cleaned with the antenna cleaner.[3] Due to the frequency with which they miss their antennae and merely draw their front legs across their eyes it would almost seem that an effort was being made to clear the eyes by means of the eye brush, a "fringe of short, stiff hairs along the anterior edge of the inner surface of the tibia,"[3] for his coming flight. However, the essential thing seems to be to clean the antennae. The same thing may be noted in worker bees, but seldom is it so elaborate or so, seemingly, necessary.

The act becomes almost comical at times when the drone twists his head about, at the same time desperately clutching for his antennae. He grasps his antenna in the antenna cleaner and then, rather slowly if there is sufficient time, draws it for the full length of the antenna. Both antennae are treated once or several times in this manner after which the drone takes off with his usual loud, characteristic buzz.

In so far as is known, drones do not visit flowers nor, indeed, do they alight at all during their flights. This is inferred from the fact that they are seldom, if ever, observed alighting in the field. Their return is heralded by the same loud hum and by complicated maneuvers from one side of the hive to the other. Sometimes these maneuvers carry them above, below, or to one side of the opening and necessitate another attempt.

THE AGE OF DRONES AT THEIR FIRST FLIGHT.

On May 18, 1932, approximately one hundred drones which had just emerged from their cells, as was evidenced by their fuzzy appearance, were marked with red or yellow and placed in a normal hive. On May 21 a drone trap was put on the hive and visits were then made at 5 P. M. each day to determine how many had attempted flight. As the drones in the trap were killed there was no possibility of repetition of flight. The results showed that one drone took his first flight

[3]Snodgrass, R. E., 1925. Anatomy and Physiology of the Honey Bee. p. 94.

four days after emergence, more took their first flights five, six, and seven days after emergence, and sixteen took their first flight eight days after emergence. From this time on the number decreased until fifteen days after emergence, when only one drone attempted flight. The average number of days after emergence that the drones took their first flight proved to be 8.41.

NUMBER OF FLIGHTS PER DAY.

On noting the entries and exits of specifically marked drones the number of flights was shown. This is expressed in Fig. 1,

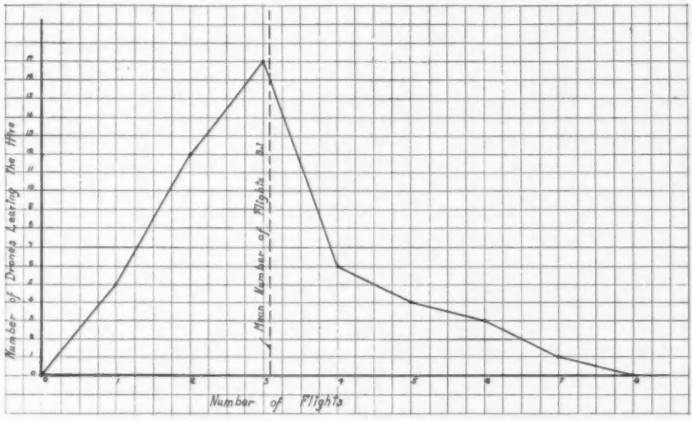

FIG. 1. Number of flights per day of drone bees for May 11, 12, 13, 14 and 15, 1932. Davis, California.

where it is shown that the greatest number of drones made three trips during the day. Taking five sunny days which seemed to be favorable to the bees an average of 3.1 flights per day was obtained.

THE AVERAGE DURATION OF THE FLIGHT.

By the same methods as used above the duration of each flight made by a drone was noted. Results are shown in Fig. 2 and indicate that the greatest number of drones remained away from the hive from one to six minutes and from twenty-five to thirty minutes. An average taken from the

same five sunny days mentioned above shows 27.34 minutes as the average duration of flight. This includes two drones which remained away for 146 and 207 minutes, respectively, and are not included in the graph. Additional experiments showed that on cloudy, cold days or on windy days the average is very much lower, 4.6 minutes for the former and 10 minutes for the latter.

The rather surprising occurrence of a bimodal curve representing the duration of flight immediately suggests that

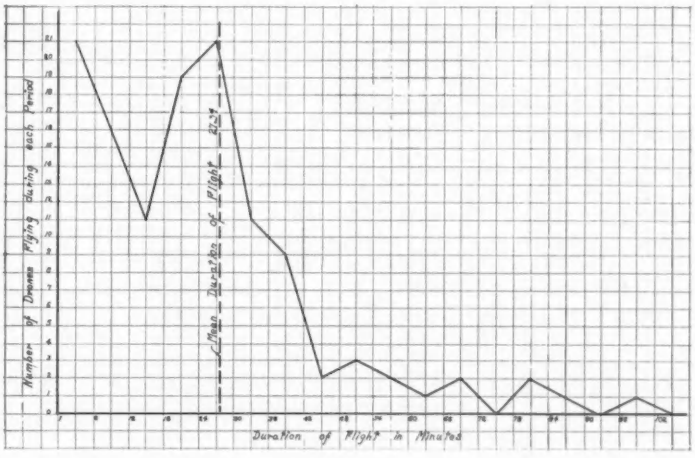

FIG. 2. Duration of flight of drone bees for May 11, 12, 13, 14 and 15, 1932. Davis, California.

perhaps drones fly for two purposes, one of which is accomplished in the shorter and the other in the longer time. Dr. J. E. Eckert has suggested the term "orientation" as best describing the shorter flight and the term "searching" for the longer one. If this assumption is correct, then it should be possible to show that the shorter orientation flights are the first flights made by the drones each day. Consulting our data it was found that of the twenty-one flights of six minutes or less, twelve of them were first flights, three second flights, three third, two fourth, and one fifth. From this it may be seen that, while not proving beyond all doubt, such a theory is at least suggested.

LENGTH OF LIFE OF AN ADULT DRONE.

Dr. J. E. Eckert marked a group of drones which had just emerged on March 23. On May 10 twelve of these were marked specifically and by subsequent observations it was determined when these dropped out, e. g., when they were no longer to be found in the brood chamber. Results indicate that these drones lived for approximately fifty-four days, some dropping out after fifty-two days and one living for fifty-nine days. Coupled with the fact that all of the drones originally marked on March 23 had disappeared by May 19, these results become rather significant, although it is recognized that no general conclusion may be drawn from such a small number of individuals. Also, as a few of the originally marked drones were found in other hives of the apiary, a possibility of error was introduced. However, the results are here presented as an indication of the probable length of life of drone bees.

HOURS OF FLIGHT.

As has been mentioned, the data for this experiment were obtained by counting all drones which entered or left the hive throughout the day. The total number flying during each hour of each of several days was first noted. Three different hives were used and observations were made on days of varying weather conditions. Several ecological factors have been considered in an attempt to correlate the results herein presented. Interesting results which have come out of this study are that the majority of drones fly between the hours of 2:00 P. M. and 4:30 P. M. The maximum flight for "normal" sunny days proved to be at 4:00 P. M. (see Fig. 3). As the temperature was the same at this time as at 10:30 in the morning, the peak being in the neighborhood of 1:00 P. M., and as no drones flew during the morning some other factor was concluded to be the important one. It seemed that relative humidity might prove to be this decisive factor as drones fly during the period of the day when the relative humidity is lowest (see Fig. 3). Also the figures for grains of moisture per pound of dry air give a curve which is very comparable to the relative humidity curve. However, Dr. S. B. Freeborn very kindly computed the saturation deficiency or actual evaporating power of the environment on the organism for the various

hours and found a curve very comparable to that of temperature (see Fig. 3) except that the peak was at 2:00 P. M.

Other factors which were considered were wind velocity, internal temperature of the hive and light intensity and wave length. It was found that a slight increase in wind velocity occurred each day at the time of the drones' flight. It was also thought that the internal temperature of the hive might have some influence on the drones. However, work by previous

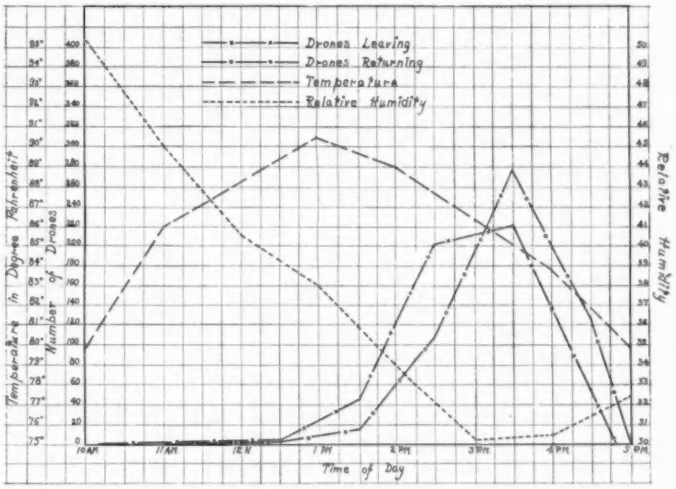

FIG. 3. Flight of drone bees correlated with temperature and humidity for May 11, 12, 13, 14 and 15, 1932. Davis, California.

authors[4] has shown this temperature to be relatively constant and the temperatures obtained by the present authors bear this out as they ranged only from 30° to 34° C. at the entrance to the hive, which is more likely to vary than the interior of the hive. Work by other authors on the flight of worker bees would indicate that light is an important factor. The authors wish to express their appreciation to Prof. W. B. Herms for his assistance in suggesting references from which the following data were obtained.

It should be recognized from the first that all of the data

[4]Gates, Burton N. Bull. No. 96, U. S. D. A., p. 20, 1914.

on light reactions of the honey bee refer to the worker bee, so that their application to studies with drones is a poor substitute for the actual experimentation which, unfortunately, must be left for the future. However, certain interesting hypotheses may be drawn from the work of Bertholf and others. It seems rather unlikely that light intensity, in itself, is very important as Bertholf[5] has shown that bees can not distinguish between two illuminated areas unless the illumination of one is reduced to an intensity seventy per cent as great as that of the other. Thus a thirty per cent difference in intensity is necessary before a bee is able to distinguish it. Ultra-violet light, on the other hand, seems to be a much more important factor. Fabry and Buisson[6] have shown that the relative energy of the sun's ultra-violet at the earth's surface in June, 1920, at Marseilles, France, was 77.27 times as great at 296.3 $\mu\mu$ as at 305.2 $\mu\mu$. Along the same line Bertholf[7] found that the stimulative efficiency in the ultra-violet spectrum for the honey bee increases rapidly from at least as low a wave length as 297 $\mu\mu$ to 365 $\mu\mu$, the efficiency at 307 $\mu\mu$ being 120 times that of 297 $\mu\mu$. From the above evidence it may be seen that ultra-violet light has a definite effect on honey bees. Added to this Luckiesh[8] found that the increase in ultra-violet wave length throughout the day showed an increase from 295.5 $\mu\mu$ at 10:30 A. M. to 307 $\mu\mu$ at 4:38 P. M., thus corresponding very well with the authors' experimental flight curve (see Fig. 3). If this continues to increase until sundown it would seem that drones should continue to fly until this time, but it is suggested that perhaps the intensity of white light may become low enough at 5:00 P. M. to become a prohibitive factor.

After all ecological factors have been considered there will always arise the question of how the drones receive the stimulus isolated as they are within the hive from temperature, which is maintained at a relatively constant degree, humidity, which is determined by the amount of honey flow and consequent rate of evaporation of nectar,[9] and light, which is shut out by

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[5]Jl. Agr. Research, 42 (7): 413–414, 1931.
[6]In Shelford, V. E., Laboratory and Field Ecology, Table 33, p. 313, 1929.
[7]Jl. Agr. Research, 43 (8):711, Fig. 3, 1931.
[8]In Shelford, V. E., Laboratory and Field Ecology, Table 32, p. 313, 1929.
[9]Phillips, E. F., Beekeeping, p. 84, 1921.

the hive. This question is omnipresent and can not be explained by the authors.

CONCLUSIONS.

In conclusion, the authors wish to say that from the accumulated evidence, which is admittedly inadequate and must therefore be used merely as an indication, until more extensive experiments throughout the year and in other localities have been performed, it appears: that drones take their first flight between four and eight days after emergence with more favoring the latter figure, that drones average three flights per day on sunny days and one flight per day on cloudy days, that the average duration of flight of drones is approximately twenty-seven minutes, that drones live approximately fifty-four days, and that drones fly in abundance between the hours of 2:00 P. M. and 4:30 P. M., with their greatest peak at 4:00 P. M.

FIGHTING THE INSECTS, THE STORY OF AN ENTOMOLOGIST, TELLING THE LIFE AND EXPERIENCES OF THE WRITER, by L. O. HOWARD. Pages i–xvii, 1–333. 1933. Published by The Macmillan Co., New York. $2.50.

This volume, as its subtitle indicates, is largely autobiographical. The Insect Menace, by the same author, emphasized more the work of the Bureau of Entomology staff and its connections abroad, while this book gives the reader the qualities of Doctor Howard's leadership, which is shown to be extraordinarily broad and human.

While the contents are divided into fifteen chapters, these are without titles, but are a series of interesting incidents, each suggesting the next. Chapter one opens with a brief sketch of the author's early life, but with Chapter II the anecdotal form of presentation begins and continues to the end of the volume. Chapters II–IX are limited largely to the early history of the Bureau and federal entomology in general. Chapters X–XV are more general, starting off with International Congresses and dealing largely with Doctor Howard's broader contacts in Washington and with his many contacts and scientific connections abroad.

It is a personal history of these things written charmingly and without indication of malice or criticism though many annoying incidents must have been interspersed with the many pleasurable incidents described. All through it one can read an argument for the life of a government scientist on a small salary. The author continually shows the compensations for the man, but he also admits that to succeed a government man must have backing him a self-sacrificing wife.

Altogether it is a volume from Doctor Howard's own heart and shows the elements of the strength of his administration of the most important entomological position in America and because of the extent of Bureau operations probably the most important entomological position in the world. It is a book that will be of interest to every American entomologist and to many in related fields.—C. H. K.

DETERMINATION OF THE SURFACE AREA OF INSECTS.[1]

W. A. SIMANTON,
Iowa State College, Ames, Iowa.

Recent advances in fields of insect physiology and insect toxicology have emphasized the desirability of sound bases for the expression of the physiological and toxicological phenomena discovered. In the higher animals the metabolic rate as determined by the respiratory quotient and the calorific output is commonly expressed with relation to body surface. The respiration of insects has been studied by many workers (Lee, 1929), several of whom have measured the oxygen intake and the carbon dioxide output. McGovran (1931) has determined the quantity of air passing through the tracheal system of the grasshopper per gram of body weight. Bodine (1921), in addition, has expressed the carbon dioxide output of certain Orthoptera not only on the basis of body weight but also as a function of the weight to the two-thirds power, the latter being a very rough approximation of the body surface. He found a much better agreement of the data when it was compared to the two-thirds power of the weight rather than to the weight alone, and has stated that the surface law probably holds for insects as well as for higher animals. Many workers in entomology would no doubt express their results with relation to body surface for the purpose of comparison with similar results available for higher animals, if the surface area of insects could be readily obtained.

This paper presents a method for the determination of the surface area of insects.

HISTORICAL.

As the accurate determination of the surface area by direct observation usually cannot be made upon the living animal, formulae have been introduced by which the surface may be computed from the body weight alone or from the weight and

[1]Contribution from the Department of Zoology and Entomology.
The author wishes to express his indebtedness to Dr. C. H. Richardson, Professor of Insect Toxicology, Iowa State College, for many suggestions and criticisms.

certain body measurements. Nearly all of these have been modifications of the surface formula given by Meeh (1879) which is, S sq. cm. $= kW^{.667}$ grams, k being a constant determined for the species. This equation is based on the law that the surfaces of similar solids are proportional to the two-thirds power of the volume with the assumption that the specific gravity is constant.

Du Bois (1924) has developed a height-weight formula for computing the surface area of man. Several workers have adapted the Meeh formula to the dog, rat, horse, cow, chicken, and swine, and in some cases have modified the original formula by the introduction of correction factors. A summary of the work on this subject is contained in a paper by Cowgill and Drabkin (1927).

No reference has been found in the literature pertaining to methods for the determination of the surface area of insects.

MATERIAL.

The two insects used in this work for which formulae have been derived were *Aphis rumicis* L., the bean aphid, and *Blattella germanica* L., the German cockroach. These insects were chosen, first, because they are both widely used as experimental material in insect physiology and toxicology; secondly, because of the great difference in their size and body shape, and thirdly, because of their availability. The insects were reared in the laboratory under nearly the same conditions although not all were from the same colony. The individual insects selected for measurement varied widely in body weight and appeared normal for the species.

All measurements of body surface were taken with a calibrated cross-ruled eyepiece fitted to a binocular microscope. An accurate analytical balance was used in obtaining the weights of the insects.

METHODS.

The experimental method used in determining the surface area of the insect was in general similar to that which has previously been used for higher animals. It consisted of dissecting the animal to such an extent that the curved body surfaces could be pressed flat and measured as plane surfaces.

The determination of the surface area of the roach was

made by the following procedure: (1) the insect was placed in a weighing bottle and carefully weighed to four decimal places; (2) the head, legs, and viscera were then removed, the legs being detached at the trochantero-femoral joint, and the visceral mass was removed by puncturing the posterior end of the body and withdrawing the digestive tract and other organs; (3) the head and legs were then placed between two glass microscope slides and gently compressed; (4) the area of one side of each of these parts was determined by means of a calibrated binocular microscope.

TABLE I.

COMPARISON OF THE CALCULATED AND THE OBSERVED AREAS OF THE COCKROACH.

Roach	Weight of Roach, Grams	Observed Area of Roach, Sq. Cm.	Area Calcd. from $S = 12.17\ W^{.63}$ Sq. Cm.	Per cent Diff. from Observed Area
1	0.0190	0.932	1.002	+ 7.50
2	0.0216	1.069	1.087	+ 1.68
3	0.0233	1.145	1.140	— 0.34
4	0.0295	1.408	1.322	— 6.11
5	0.0401	1.579	1.604	+ 1.60
6	0.0455	1.710	1.738	+ 1.64
7	0.0491	1.885	1.823	— 3.29
8	0.0636	2.229	2.146	— 3.72
9	0.0694	2.271	2.267	— 0.17
10	0.0782	2.397	2.447	+ 2.09
Mean.....	.....	.....	.....	± 2.81

The area of the trochanters, which remained with the body, was also measured and this area, together with the areas of the legs and the head, was added to the area of the body. As these areas were for one side only the measurement was doubled and the total body surface in square centimeters was computed. The surface obtained by this method is given in Table I.

The procedure in the case of the aphids was in general similar to that for the cockroaches. Five aphids, of as nearly uniform size as could be determined by the low power microscope, were placed in a weighing bottle and weighed. The tip of the abdomen of each aphid was punctured with a needle. The insects were then placed between two glass microscope slides and gently compressed. The body contents passed through the puncture thus preventing the insect from becoming

abnormally distended. The surface area of the aphids so prepared was measured by means of a calibrated binocular microscope.

The following method was used to derive a formula for the direct determination of the body surface area from the body weight:

A mathematical formula was fitted to the measurements obtained from observation by modifying the expression,

$$S = k\,W^n$$

in which S is the surface area in sq. cm., k the constant for the species, W the weight in grams and n the power of the weight.

TABLE II.

COMPARISON OF THE CALCULATED AND THE OBSERVED AREAS OF THE APHID.

Lot of Five Aphids	Weight of Five Aphids, Grams	Av. Wt. of One Aphid Grams	Average Observed Area per Sq. Cm.	Area Calcd. from $S = 3.28\ W^{.6}$	Per Cent Diff. from Observed
1	0.0031	0.00062	0.0423	0.0390	— 7.80
2	0.0032	0.00064	0.0374	0.0397	+ 6.15
3	0.0036	0.00072	0.0419	0.0427	+ 1.91
4	0.0039	0.00078	0.0484	0.0448	— 7.45
5	0.0042	0.00085	0.0449	0.0477	+ 6.24
6	0.0048	0.00096	0.0536	0.0507	— 5.41
7	0.0050	0.00100	0.0524	0.0520	— 0.76
8	0.0057	0.00114	0.0558	0.0562	+ 0.72
9	0.0061	0.00122	0.0548	0.0586	+ 6.93
10	0.0064	0.00128	0.0582	0.0603	+ 3.61
Mean....	.....	.....	.....	.....	± 4.70

The necessary values were obtained by computing k when n was varied between 0.4 and 0.8 for each individual case throughout the range in weight. The standard deviation of the mean value for k when a definite value for n was used, was determined and expressed as a per cent of the mean value of k. Statistically, the value obtained is the coefficient of variation of each individual k from the average k and is expressed by the formula, $V = \frac{\sigma}{M} \times 100$. This number becomes larger or smaller when the value of the exponent is changed. The value for n at which the standard deviation as a per cent of the mean k was at a minimum was the exponent which best fitted the data. Logarithms were used in making the calculations. Figure 3

gives a graphic presentation of this procedure applied to the data from the cockroach.

ANALYSIS OF DATA.

The data obtained from the cockroaches are given in Table I. The columns show the comparison of the surface areas calculated by the formula $S = 12.17\ W^{.63}$ to those areas obtained by observation throughout the range in weight. The average

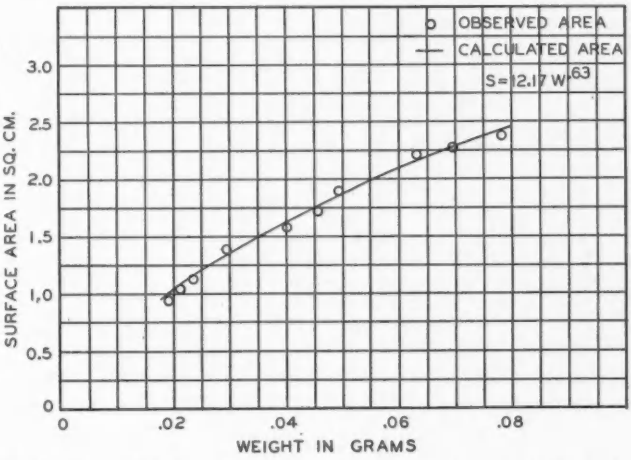


FIG. 1. Comparison of the calculated and the observed areas of the cockroach.

per cent of difference between the calculated and the observed areas is ±2.81, with a maximum of 7.5 per cent. This data is graphically presented in Figure 1. It is interesting to note that the experimental points fall into three groups probably representing the second, third, and fourth instars, since out of twenty-four roaches none fell between the weights of 3 and 4 grams nor between 5 and 6 grams.

Table II presents the data obtained from the aphids. The average per cent of difference between the observed surface and that calculated from the formula $S = 3.28\ W^{.60}$ is ± 4.7, with a maximum deviation of 7.8 per cent. The greater deviation in this case is probably due to the difficulties involved in obtaining aphids of uniform size and to errors in weighing. Figure 2 presents this data in graphic form.

Figure 3 illustrates the method of determining the correct exponent for use with the surface weight formula as applied to the data for the cockroach given in Table I. The value of the exponent at which the standard deviation of k in per cent of average k is at a minimum, is shown to be 0.63.

DISCUSSION.

The methods described in this paper for determining the surface area of insects by observation, and for establishing a formula by which surface area can be calculated, are probably

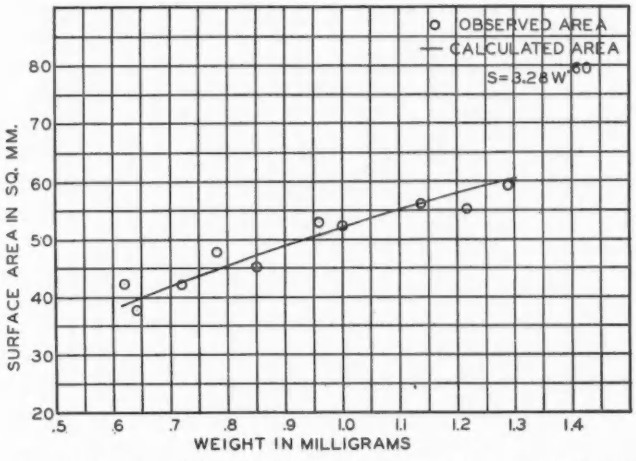


FIG. 2. Comparison of the calculated and the observed areas of the aphid.

applicable to most insects. Insects such as the grasshoppers, beetles, true bugs, etc., can be dissected to such an extent that the flattened surfaces are readily measured. Measurements have been easily obtained on a few species other than those used in this work. The measurements obtained by observation did not include wing surfaces. In winged forms, therefore, the weight and area of the wings must be obtained separately and added to the area obtained by formulae or observation. No attempt was made to evaluate the tracheal surface.

Formulae applied to insects with size and body shape similar to that of the roach or the aphid will be similar to the formulae given herein. The value for the exponent of the

weight will fall between 0.55 and 0.75 for most insects, whereas the value for the constant may vary considerably depending upon size and body shape of the particular species.

The accuracy of the methods of observation and the accuracy of the formulae compare very favorably with the accuracy of formulae determined for other animals. For comparison several formulae are here listed:

German cockroach..... $S = 12.17\ W^{.63}$
Bean aphid..... $S = 3.28\ W^{.60}$
Dog..... $S = 6.67\ W^{.70} \times f$ (nutritive factor)
Rat..... $S = 11.4\ W^{.667}$
Dairy cattle..... $S = 26.99\ W^{.56} \times f$ (nutritive factor)
Swine..... $S = 10.72\ W^{.63} \times f$ (nutritive factor)

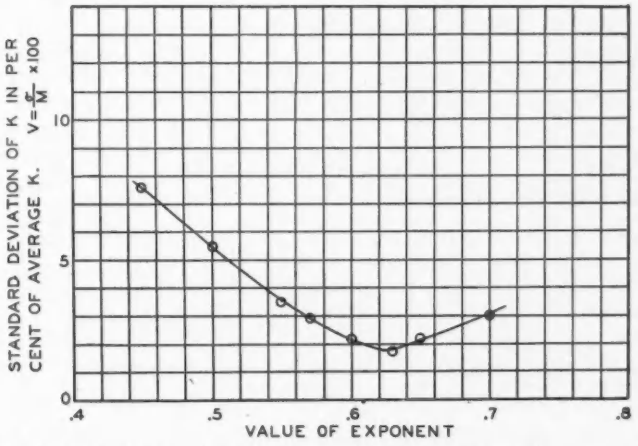


FIG. 3. Method of determining the best value of the exponent for use with the formula, applied to the data from the cockroach.

The average deviation of the calculated from the observed areas is between ± 2 and ± 5 for any of the above formulae. The nutritive factor f present in several of the formulae has been introduced to correct for the degree of fatness of those individuals which vary from the normal state of nutrition. Because of the difficulties encountered in ascertaining the state of nutrition of the above insects it did not appear advisable to attempt to determine this factor. It is quite probable that a factor could be introduced to give a more accurate estimation of the surface area of newly molted individuals. It is believed, however, that this correction would be small.

SUMMARY.

A practical method has been developed for determining the surface area of insects by dissecting and compressing the body and measuring the areas of the parts by means of a calibrated microscope.

Formulae have been fitted to the measurements obtained by the above method of observation by which the surface area of two species of insects may be calculated from the body weight.

The formula determined for *Blattella germanica*, the German cockroach, is $S = 12.17\ W^{.63}$ and that for *Aphis rumicis*, the bean aphid, $S = 3.28\ W^{.60}$. The method of obtaining these formulae has been described and illustrated.

The results obtained with the two insects compare very favorably with the results previously obtained with higher animals, regarding both accuracy of method and similarity of formulae.

LITERATURE CITED.

Bodine, J. H. 1921. Factors Influencing the Water Content and the Rate of Metabolism of Certain Orthoptera. Jour. Exp. Zool. 32 (1): 137–164.

Carman, G. G. and **Mitchell, H. H.** 1926. Estimation of the Surface Area of the White Rat. Amer. Jour. Physiol. 76 (2): 380–384.

Cowgill, G. R. and **Drabkin, D. L.** 1927. Determination of a Formula for the Surface Area of the Dog together with a Consideration of Formulae Available for Other Species. Amer. Jour. Physiol. 81 (1): 36–61.

Du Bois, E. F. 1924. Basal Metabolism in Health and Disease. New York, Lee and Febiger.

Lee, M. O. 1929. Respiration in the Insects. Quart. Rev. Biol. 4: 213–232.

McGovran, E. R. 1931. A Method of Measuring Tracheal Ventilation in Insects and Some Results Obtained with Grasshoppers. Ann. Ent. Soc. Amer. 24 (4): 751–761.

Meeh, K. von. 1879. Oberflächenmessungen des menschlichen Körpers. Zeitschr. für Biol. 15: 425–458.

THE MOTHS OF SOUTH AFRICA, by A. J. T. Janse. Vol. I, 375 pages, 130 text figures and 15 plates with 320 figures. Published by Pretoria University, Pretoria, S. Africa. Bound, 35 shillings.

This is the first of what promises to be a comprehensive ten-volume work on the moths of South Africa. The work is based on the material in the Museums of South Africa, the author's collection and material in the British Museum. It is very thoroughly illustrated with drawings of male genitalia and photographs of the moths.—C. H. K.

ECOLOGICAL STUDY OF THE PTILIID MYRMECOCOLE, LIMULODES PARADOXUS MATTHEWS.

ORLANDO PARK,
University of Illinois.

The occasion for this study arose when I discovered on August 7 a small colony of *Aphaenogaster fulva aquia* Emery[1] entrenched under a moist board in my yard. On closer examination a number of minute beetles were seen running about with the ants in the confusion of the opened nest. On one of the brood piles a number of the beetles were found clustered. Consequently a part of the nest was removed for laboratory observation.

The colony yielded thirty workers, about one-fourth of which were callows, six eggs, sixteen larvae and eight pupae in various stages of development. With these were taken twelve beetles, most of which were clinging or whisking over the ant brood, even when the latter was being transferred to a bottle.

Part of these minute beetles were killed, dehydrated and mounted whole, others dissected in 50 per cent alcohol and the structures mounted separately. This latter method was the only way in which the mouth parts could be studied satisfactorily. These small beetles were found to be *Limulodes paradoxus* Matthews (Ptiliidae = Trichopterygidae).

The ptiliids, probably as a consequence of their small size of usually less than a millimeter, are not often recorded from the nests of ants. An extensive search for this family in ant nests over the world would undoubtedly bring much new ecological and taxonomic material. Thus Donisthorpe (1927) lists seven species in *Trichopteryx*, *Ptilium*, and *Ptenidium* from nests of British ants. The number of European records is much greater. Records for North America are scarce. *Ptenidium pusillum* Gyll. was reported with ants by Schwarz (1890), but no host was mentioned and Schwarz thought the beetles accidentally in the nest. Wickham (1892) mentions *Acratrichis parallelopipeda* Matth. with a species of *Tapinoma* in Colorado.

[1]I am indebted to Drs. M. R. Smith and Thomas Park for the determination of the host ants used in this study.

With respect to *Limulodes paradoxus* Matt. there can be no doubt as to its myrmecocolous habits. This species was reported from nests of *Lasius aphidicola* Walsh by Schwarz (1890) and Wickham (1892); with *Aphaenogaster fulva* Rogers by Wickham (1892, 1896) and with *Formica obscuripes* Forel by Wickham (1896).

Its occurrence with ants is established, then, but as with all other instances where ptiliids are cited with such hosts, little or nothing is mentioned beyond host species, date and locality. This paucity of data may render the following observations of interest.

Artificial nests were set up in the laboratory and various combinations of worker ants, developmental brood stages and beetles observed under a dissecting binocular (40 to 80 diameters). This served for most of the work, but to observe the minutiae of feeding a depression slide was used and the concavity walled with a circular ring of modeling clay to a height of five millimeters. Then an ant larva or pupa and beetles were placed in this cell and the wall roofed with a cover slip. Such prepared cells could then be examined with the compound microscope with success. The beetles and host brood are translucent and both reflected and direct lighting of the stage gives an accurate picture of activities within the cell. Such examinations were made regularly but for a short time to avoid heating of the cell by the light of the lamp. The clay wall was desirable, as its height could be adjusted at will and consequently crush out larval or pupal body fluids without losing track of the occupants of the cell.

Limulodes paradoxus is a minute species, averaging one millimeter long by half a millimeter at the widest point, viz., through the basal third of pronotum. It is wedge-shaped with the pronotum broadly rounded anteriorly and the head not or just visible from above. Posteriorly, the pronotum dilates and then curves into the base to envelope the elytral humeri. This rounded contour is followed by the margins of the elytra which curve mesiad, and finally the extremely tapered abdomen. Thus superficially it appears similar to many of our small Staphylinidae which frequent the nests of ants and termites over the world (the tachyporine termitocoles of *Trichopsenius;* the aleocharine myrmecocoles such as the tropical *Xenocephalus, Ecitoxenus heyeri* Wasm., etc.). Many such loricate

synoeketes are well known, their structural convergence has been discussed (Wheeler, 1926) and the species figured (Wasmann, 1900, 1904 a, b).

In *paradoxus* the appendages are normally hidden beneath the overhanging pronotal and elytral margins so that observation of tarsal, antennal and mouth part activity is best seen from the side. The contractile abdomen can be drawn beneath the elytra and in this condition the beetles are just on the range of unaided vision. The coloration of this species is similar to that of the host workers, being a dark, glistening brown. The movements of the beetles are of interest. They are capable of rapid, prolonged walking and when stimulated they can run as swiftly as the host workers. Flight is impossible since (1) the wings are reduced to mere vestigial pads, (2) the elytra groove into each other along the suture, and (3) the pronotum has the posterior angles produced, and these latter very probably lock on either side with the elytral humeri. Each of the humeri bears an elongate ridge which is transversely striate, and one wonders if these humeral ridges are for locking only, or for stridulation, or both.

When feeding the beetles are seldom still, having a habit of suddenly skipping about. Such movements are very short, being usually less than the beetle's length. The short antennae wave or palpitate over the food and at intervals the abdomen, antennae and tarsi quiver or vibrate rapidly for a few seconds. The distal, aciculate fourth segments of the maxillary palpi are applied at right angles to the larval or pupal integument, and keep up a continual tapping. Apparently the essential role in feeding is performed by the maxillae *per se*. The rounded extremities of the galeae are mesially and obliquely convex and bear some seven to nine rows of very minute, backwardly directed setae, transforming each organ into an exquisitely adjusted combing structure. Matthews (1872) figures the maxillae incorrectly, and assigns to each galea a large tuft of forwardly pointed hairs. The galeae move in an arc back and forth over the feeding surface and integumental exudates and foreign material are swept up by their feeding brushes and conveyed into the mouth by the toothed laciniae and the slender, sickle-shaped, inconspicuous mandibles. The regular, rapid movements of both lobes of the maxillae and mandibles remind one of the activity of the rotiferan mastax.

After feeding, the prothoracic legs, antennae and palpi are often cleaned by drawing them through the maxillae and mandibles.

The food of *paradoxus*, so far as examined, is the surface oils and sundry accumulations of (1) the integument of the host brood, and where this is not available, (2) of the host worker's integument. The host brood is always attended by the swarm of *Limulodes*. Three of them were observed on a larva when the nest was uncovered and in the laboratory nests the beetles practically never quit the brood of their hosts. They move when the brood is moved by the workers, either (1) skipping along after the laden ants, (2) being transported on the larvae and pupae, or (3) riding the ants themselves (*vide infra*). Their minute size allows a number of beetles to feed upon one pupa. Five to nine of them have been observed frequently on or about a single pupa. The usual scene is that of each larva or pupa being attended by ants and from two to three of the beetles (Fig. 1).

Consequently the brood is the center of nest activity. Both host and beetle lick and scrape side by side, and apparently not visibly stimulated by each other's proximity. The writer is familiar with few more complete cases of indifference accorded myrmecocolous insects. Only once in this study a worker ant was seen to bite at a beetle, and in this case the latter evaded attack easily by crawling rapidly up the legs of the worker. Often in licking one of the brood, an ant would inadvertently push a beetle aside with her fore-tarsi or mandibles. In moving the brood, a worker would often have to pick up its burden in an awkward manner since the available integument would be occupied by the beetles.

This assiduous scraping of the host brood by *paradoxus* did no appreciable harm. As far as the adult beetles are concerned, their feeding activities may even be beneficial since the beetles were not seen to gnaw, but to scrape and lick the brood integument, after the manner of attending ants. The ant pupae matured daily, becoming darker and finally shedding the pupal cuticle, aided by the workers who stripped off the shreds of cuticle from the appendages, and licked by the beetles as well. The ant larvae also seemed unhurt by the beetle's scraping, and chewed with their minute mandibles what appeared to be shreds of pupal cuticle probably given them

by the zealous ant nurses. Larvae have been observed chewing away and being scraped by both ants and beetles.

The ant eggs were scraped least by the beetles, the larvae attended more regularly while the pupae were scraped from an early stage through pupation. This is probably to be expected in view of the predilection of the beetles for integumental exudations.

Another interesting point is the transportation of *paradoxus* by the ants. This may be indirect, the beetle being carried while on an ant larva or pupa; or directly on the worker's body. I do not know whether this riding is merely phorecy, or linked with the feeding of the beetles. The latter is much more

Fig. 1. Pupa of *Aphaenogaster fulva aquia* with three *Limulodes paradoxus* scraping and licking its integument.

probable. When the ants are removed from a nest the beetles usually run rapidly about, in contrast to their normal circumscribed activity. When the brood is removed the beetles tend to ride the worker ants more. I have seen a beetle leap from an earth clod on to the head of a passing ant and cling for several seconds. In such cases the beetle was usually scraped off by the ant. However, the ants were not always able to dislodge the beetles. On one occasion a beetle climbed up the gaster of a crouching ant while she attended an ant larva already burdened with two *paradoxus*. The beetle stayed on the gaster for three minutes without feeding, and then climbed down to the nest floor. To cite one more of a long series of observations, a worker ant deposited a larva in the shelter of a nest clod and a beetle came up and ran from the head of the larva up the ant's mandibles to the vertex of the worker's head. Subsequently the ant picked up the larva and started away, but before the larva had cleared the nest a second beetle ran up this improvised gang-plank to the ant's head.

The two beetles on the head then took respective positions, one just posterior to each eye, apparently balancing the load after the manner of many ectoparasitic gamasoids. The ant, with a beetle scraping and licking away near each eye, moved off with the larva.

From this it is clear that *Limulodes paradoxus* rides upon the host ants. Such transportation may or may not be accompanied by scraping the host integument for food, and the host may or may not attempt to rid itself of passengers. The beetles may spring from above or climb up the legs, head or gaster of the host and transportation may be direct on the ant's body or indirect on the brood.

The ecological position of this species of beetle in the *Aphaenogaster aquia* biocoenose may be suggested by a review of its morphological and behavioristic adjustments. We have a minute species of unknown life history which has been shown in previous literature to be found with several species of ants. This myrmecocolous niche is probably obligatory. The tapered form and general color is paralleled by many ant and termite nest staphylinids. Extensive specialization is seen in the flightless, vestigial wings, intergrooving elytra, and absence of compound eyes. The species is not persecuted by the host ants; its scraping activities in feeding may even be considered beneficial since they parallel the brood ministration by the host. In common with other synoeketes and symphiles studied by the writer (Park, 1929, 1932 a, b, 1933), this ptiliid takes its nourishment, at least in part, from the host brood. However the beetles further feed in part upon integumental accumulations of the host workers. The view held by Wheeler (1926, p. 383) for a number of myrmecocolous Ptiliidae as neutral synoeketes, viz., obtaining most of their food as scavengers on the nest refuse, cannot be accepted for *L. paradoxus*. Consequently we have in the latter species a demonstrably loricate synoekete. It may be one of those forms entering a more intimate association with ants. Since its mouth-parts are not those of a carnivore, e. g., the galeae bearing scraping brushes, and the weak and inconspicuous mandibles, a return to a less specialized predatism as found in so many synecthrans and synoeketes is hardly tenable. This is supported by the fact that most Ptillidae live either in decaying log or leaf mold or in fungi, and many of these have mouth-parts similar to those of

paradoxus. Although the food of these free-living ptiliids is not generally known, predatism is not to be expected.

It seems to the writer that we have in *Limulodes paradoxus* a species of specialized structure and behavior which argues for a long association with ants and a high degree of commensalism upon the ant community.

LITERATURE CITED.

Donisthorpe, H. St. J. K. 1927. The Guests of British Ants. London: George Routledge and Sons, xxiii + 244 pp.

Matthews, A. 1872. Trichopterygia illustrata et descripta. London, 188 pp.

Park, Orlando. 1929. Ecological Observations upon the Myrmecocoles of *Formica ulkei* Emery, Especially *Leptinus testaceus* Muller. Psyche, **36**: 195–215.

1932a. The Myrmecocoles of *Lasius umbratus mixtus aphidicola* Walsh. Ann. Ent. Soc. Am., 25: 77–88.

1932b. The Food of *Batrisodes globosus* (Lec.). Jour. N. Y. Ent. Soc., **40**: 377–379.

1933. The Food and Habits of *Tmesiphorus costalis* Lec. Ent. News, (in press).

Schwarz, E. A. 1890. Myrmecophilous Coleoptera Found in Temperate North America. Proc. Ent. Soc. Wash., **1**: 237–247.

Wasmann, E. 1900. Neue Dorylinengaste aus dem neotropischen und dem athiopischen Faunengebiet. Zool. Jahrb., **14**: 1–75.

1904a. Zur Kenntniss der Gaste der Treiberameisen u. ihrer Wirthe am obern Congo. Zool. Jahrb., Suppl. **7**: 611–682.

1904b. Die phylogenetische Umbildung ostindischer Ameisengaste in Termitengaste. C. R. Congrès inter. de Zoologie, Berne, pp. 436–448.

Wheeler, W. M. 1926. Ants, Their Structure, Development and Behavior. Columbia Univ. Press, N. Y., xxv + 663 pp.

Wickham, H. F. 1892. On Myrmecophilous Coleoptera. Psyche, 6: 321–323.

1896. On Coleoptera found with Ants. III. Psyche, **7**: 370–372.

THE HISTORY OF THE ENTOMOLOGICAL SOCIETY OF LONDON, 1833–1933, by S. A. NEAVE, *Honorary Secretary*, assisted by F. J. GRIFFIN, *Registrar*, with an Introduction by E. B. POULTON, *President*, and a Financial Chapter by A. F. HEMMING, *Honorary Treasurer*. Pages i–xlvi, 1–224 and 8 plates. London, 1933.

This is a centenary volume anticipating the celebration of the Centenary of the Entomological Society of London which occurs this year. The contents are as follows: The Charter and By-Laws; Introduction; Chapter I, Origin and Foundation, 1745–1833; II, Rise and Progress, 1834–1847; III, 1848–1856; IV, 1856–1870; V, 1871–1885; VI, 1886–1918; VII, 1919–1933; VIII, The Collections; IX, The Library; X, The Publications; XI, The Finances. Then follow: Benefactions, Biographies of Some Distinguished Fellows (twenty in all), a list of Officers and Fellows and a table showing the Growth of the Fellowship, (156 in 1833 to 685 in 1932). Index.

The material is largely from the records of the Society and thus makes available a mass of very interesting and valuable information. The eminence of the Entomological Society of London in its field is readily understood as the reader notes the names of distinguished men on every page of its history. We wish for the Society equal distinction in the coming century.—C. H. K.

SOME FALSE SCORPIONS OF THE ATEMNID SUBFAMILY MIRATEMNINAE.

(Arachnida—Chelonethida.)

JOSEPH CONRAD CHAMBERLIN,
Associate Entomologist, U. S. Bureau of Entomology,
Twin Falls, Idaho.

The subfamily Miratemninae of the family Atemnidae has been erected by Beier (1932) to include the single genus *Miratemnus*, under which he recognizes two species. It is of interest to be able to add two additional genera and four species to the group at this time.

The writer strongly concurs with Beier in his recognition of this subfamily, having in fact recognized it as such for several years under a manuscript designation on the basis of the forms hereinafter described.

Literature citations (indicated by chronological designation) refer in all cases to the terminal bibliography.

Family **Atemnidae** Chamberlin.

1931. *Atemnidae*, Chamberlin, p. 243.
1932. *Atemnidae*, Beier, p. 548.

Subfamily **Miratemninae** Beier.

1932. *Miratemninae*, Beier, p. 608.

Diagnosis (emended).—Carapace granulate or distinctly squamotessellate; with two distinct transverse furrows (Pl. I, Figs. P and Q); true eyes or distinct eye-spots present. Fixed finger of chelicera with the normal complement of setae (five in all), the sub-basal seta being present (Pl. I, Fig. L), (absent in the Atemninae). Pseudotactile seta of the fourth tarsus almost submedian in position, being removed one-third or more the tarsal length from its base (Pl. I, Fig. K). Vestitural setae of dorsal sclerites and palps thickened, short denticuloacuminate or short and abruptly acuminate. Flagellum as in family, with four blades.

Remarks.—The three genera herein recognized may be separated by means of the following key:

KEY TO TULLGRENIUS, DIPLOTEMNUS AND MIRATEMNUS.

1. All tactile setae of fixed finger, with the sole exception of ET, basally and sub-basally clustered (see Chamberlin, 1931, p. 143, Fig. N); setae IT

and IST practically basal and nearly transversely opposite; T of movable finger absent; dorsal vestitural setae short and thickened; with eye-spots only; tergites and sternites entire. (Page 263)..... **Tullgrenius**

Tactile setae of chela normally distributed, not basally concentrated as in the foregoing (Pl. I, Figs. D and E); T of movable finger present; vestitural setae acuminate or denticulo-acuminate; with true eyes or eye-spots; tergites and sternites divided in part at least..... 2

2. With true corneate eyes; with at least the two anteriormost blades of the flagellum denticulate (Pl. I, Figs. T, U, and V); all tergites (1 to 11) divided into scuta. (Page 264)..... **Diplotemnus**

With eye-spots only; with only the anteriormost blade of the flagellum denticulate; tergites in part obscurely divided..... **Miratemnus**

Tullgrenius genus nov.

Orthotype. *Tullgrenius indicus* sp. nov.

Diagnosis.—Character of blades of flagellum unknown; subapical lobes of lamina interior unknown; all the usual cheliceral setae present, B, SB, and ES subequal in length and terminally or subterminally denticulate; apical and basal teeth of serrula exterior not known; galea of male (female unknown) small and obscurely branched, probably sexually dimorphic. Chaetotaxy of chela unique by reason of the basal concentration of the tactile setae of the fixed finger with the single exception of ET, which as normal is still subterminal, (See Chamberlin, 1931, p. 143, Fig. 38, N); nodus ramosus of venom apparatus distinctly (three to four areolar diameters) caudad of ET; EST almost basal in position and twice as far from ET as from ESB; EB and ESB about two areolar diameters apart and almost basal in position; IT and IST transversely opposite and about opposite ESB; ISB and IB opposite and caudad of EB and ESB; T of movable finger absent (always?); B and SB two or three areolar diameters apart and subbasal in position; sense spots few but some do occur on the interior face of the movable finger at least; dental profile of both fingers straight; chela probably not markedly sexually differentiated as in *Diplotemnus*. Carapace with the anterior furrow procurved and situated slightly posterior to median; posterior furrow slightly recurved and midway between the anterior furrow and the posterior carapacal margin; eye-spots distinct; carapace, tergites, and palps distinctly and uniformly granulotessellate; vestitural setae short and distinctly thickened. Tergites and sternites entire and uniseriately setose; third tergite markedly "narrowed." Pleural membrane evenly plicate. Tracheal trunks smoothly striate. Legs normal; tarsus IV with a pseudotactile seta one-third of the segment's length removed from its base.

Remarks.—This distinctive genus is known at present only from its orthotype. It is not at all closely related in a generic sense to either *Diplotemnus* or *Miratemnus*.

This genus is respectfully dedicated to Dr. Albert Tullgren, of Sweden.

Tullgrenius indicus sp. nov.
Plate I, Fig. A.

Previously published illustrations.—Illustrations of the palp and chela have already been published by the writer (Chamberlin, 1931, p. 115, Fig. 27, B, and p. 143, Fig. 38, N).

Holotype.—Male, (JC–541.01001) from "Guindy, Chingleput Dt. India." Collected by F. H. Gravely, 24–26–11. Deposited in the Madras Museum. I am indebted to Dr. Gravely for the privilege of studying this specimen. No other material is known.

Diagnosis.—Carapace normal, about as long as broad behind; longer than either femur or tibia but shorter than chela. Chelicerae normal; galea short and small with two or three minute terminal branches (in male); serrula exterior with 21 blades; fixed finger of chelicera with three minute teeth preceded basally by four larger ones which become progressively smaller posteriorly; lamina interior not observable in holotype. Chela normal, without any marked sexual modifications; movable finger with about 50 contiguous teeth, fixed finger with about 42; tactile chaetotaxy of chela as described under generic heading (see also Chamberlin, 1931, p. 143, Fig. 38, N). Palps robust, the tibia especially so (see Chamberlin, 1931, p. 115, Fig. 27, B); trochanter 1.36 times as long as broad; femur 2.0 times as long as broad; tibia 1.8 times as long as broad; chela 2.6 times as long as broad; fingers shorter than hand; tibia shorter than femur, which in turn is shorter than the hand. Carapacal furrows not prominent; carapace bordered posteriorly by about ten short, thickened setae and four to six lyrifissures; first three tergites narrowed, the third most distinctly so; the tergites each bordered by about ten short, stout setae; some with a single lateroanteriorly placed seta in advance of the normal border series; maxilla with an apical diamond-shaped group of four setae; coxal area typical; legs typical, the fourth femur markedly thickened. Sternites lightly sclerotized, with 10 to 12 acuminate border setae and five to six border lyrifissures, also scattered microlyrifissures. Male genital structures distinctive (Pl. 1, Fig. A). The figure shows these organs in the distorted position actually seen in the cleared specimen, the structures not being sufficiently well known to permit a reconstruction. Anterior stigmatic plate with three dwarf acuminate setae; posterior stigmatic plate with but a single seta. Length of adult male (holotype), 2.98 mm.; greatest abdominal breadth, 1.3 mm.

Diplotemnus genus nov.
Plate I, Figs. B to W.

Orthotype. *Diplotemnus insolitus* sp. nov.

Diagnosis.—Flagellum of four blades, of which the anterior two at least are dentate; lamina interior with three to five dentate subapical

lobes; both basal and subbasal setae of chelicera present and both subterminally or terminally denticulate; exterior seta simple and acuminate. Galea sexually differentiated, small and obscurely branched if at all in the male; larger with distinct simple branches in the female. Nodus ramosus of venom apparatus much posterior to seta ET, midway between ET and EST; IT approximately opposite nodus ramosus; EST almost median between ET and ESB; ESB closely paired with EB and subbasal in position; ISB and IB nearly transversely opposite and clearly distad of ESB and EB; IST opposite EST and nearer it than ISB; ST of movable finger almost median in position and nearly equidistant from T and B; SB two to three areolar diameters distad of B; B about as far from T as from base of finger; T as far from tip of finger as from SB. A few sense spots occur on the fingers of the chela. Accessory (pseudo-) tactile seta of movable finger of chela not observed; dental profile of fixed finger convex, of movable finger concave, especially near the tip. Carapace bearing two true corneate eyes which are well removed from the anterior margin; cucullus distinct; with two well defined transverse furrows of which the anteriormost is submedian in position and laterally procurved; posterior furrow nearly straight and nearer the posterior margin of the carapace than the anterior furrow. Carapace finely but distinctly granulate; tergites squamotessellate; palps, excepting fingers, evenly granulate; vestitural setae short and "thick," bluntly acuminate or minutely denticulate, nearly acuminate. All tergites and sternites longitudinally divided by a nearly linear suture. Tergites and sternites uniseriately setose. Pleural membrane smoothly plicate; tracheal trunks smoothly striate. Legs normal, tarsus IV with a slender acuminate pseudotactile seta one-third of the tarsal length removed from its base.

Remarks.—This genus, which finds its closest relative in *Miratemnus*, includes at present three species which may be separated by means of the following key:

KEY TO SPECIES OF DIPLOTEMNUS.

1. Tibia distinctly shorter than either hand or femur; tibia less than twice as long as broad; male galea stylet-like, unbranched; vestitural setae of dorsal sclerites and palps "very short and thick but scarcely clavate." (African species, Page 266) ..... **garypoides**

   Tibia distinctly longer than either hand or femur; tibia distinctly more than twice as long as broad; galea of male with vestigial branching; vestitural setae either denticulo-acute or bluntly acuminate 2

2. All four blades of flagellum denticulate; vestitural setae short and almost acuminate, with at most very minute denticulations; male genitalia as shown in Pl. I, Fig. B. (Himalayan species, Page 267) ..... **insolitus**

   Only the two anteriormost blades of the flagellum denticulate; vestitural setae thickened and terminally conspicuously denticulate; male genitalia as shown in Pl. I, Fig. C. (From St. Paul's Rocks, in the mid-Atlantic Ocean, Page 266) ..... **insularis**

Diplotemnus garypoides (Ellingsen).

1906. *Chelifer garypoides* Ellingsen, Ellingsen, p. 258.
1912. *Chelifer garypoides* Ellingsen, Ellingsen, p. 78.

Remarks.—Ellingsen's original description by itself is inadequate to permit the certain generic placement of this species in a modern classification, but its close apparent similarity to *insularis* sp. nov., the type material of which was indeed originally referred to *garypoides* by With (1908, p. 15), makes this disposition seem very likely. I can not agree with With that the difference between his material and Ellingsen's description are of less than specific value. In consequence the species *insularis* hereinafter discussed is erected. It is of course possible that Ellingsen's measurement of the palpal tibia, the proportions of which constitute the greatest apparent difference between the two forms, was in error, and reexamination of Ellingsen's types may show that actually *insularis* is truly synonymous or perhaps only subspecifically distinct. On the other hand it is equally possible that other even more marked differences may be revealed. In the meantime I believe that the tentative specific distinction of these two forms is the most advisable. Ellingsen studied five male specimens of this species from Bhamo, Portuguese Guinea.

Diplotemnus insularis sp. nov.

(Pl. I, Figs. C, G, R, S, and T.)

1908. *Chelifer garypoides* Ellingsen, With, p. 15, Figs. (Misdetermination)
1931. *Atemnus garypoides* (Ellingsen), Chamberlin, p. 115, Fig. 27, A. (Misdetermination)

Holotype.—Male, (JC–559.01001); paratypes, four males and two females. All from birds' nests on St. Paul's Rocks in the mid-Atlantic. Collected in August by the Challenger Expedition. Holotype in the Stanford University Collections (obtained by exchange from the British Museum); paratypes all in the British Museum labeled *Chelifer garypoides* Ellingsen (With's determination).

Remarks.—With's extensive description and figures together with the supplementary figures included herein may be considered to define the species. The writer (t. c.) has also published elsewhere a detailed figure of the male chela.

The principal features in which this form seems to differ from *garypoides* have been previously indicated in the

accompanying key and the reasons for segregating it from *garypoides* have been previously discussed under that specific heading.

Contrary to With's observations the first tergite *is* divided, as is clearly shown by an examination of a cleared specimen.

Diplotemnus insolitus sp. nov.

(Pl. I, Figs. B, D, E, F, H, I, J, K, L, M, N, O, P, Q, U, V. and W.)

Holotype.—Male, (JC–512.01001); allotype, female (JC–512.01002) and paratype, female (JC–512.01003). Collected by E. C. Fisher in the "N. W. Himalayas," probably in or near Kabul or Lahore, India. Holotype and allotype in the collections of the British Museum, labeled with the manuscript name of *Orochelifer insolitus* Chamberlin. Paratype in the Stanford University Collections. Studied through the courtesy of Dr. Stanley Hirst.

Diagnosis.—Carapace normal for the genus, slightly broader posteriorly than long (Pl. I, Figs. O, P, and Q); tergites and sternites normally divided by a narrow interscutal stripe; tergal scuta about 2.7 times as broad as long; tergites distinctly squamotessellate; tergites bordered by 8 to 10 nearly acute setae; sternal chaetotaxy similar except there are 10 to 12 acute border setae; last sternite with a submedian pair of pseudotactile setae. Vestitural setae almost or quite bluntly acute, at most with a minute terminal denticle (Pl. I, Fig. N). Anterior stigmatic plate with three setae, posterior with a single, dwarf seta; coxae normal (Pl. I, Fig. W). Chelicerae normal (Pl. I, Figs. L and M); with four or five (both numbers occur) dentate subapical lobes (Pl. I, Fig. M). Serrula exterior with 22 to 23 teeth. Galea of male vestigially branched (Pl. I, Fig. F); galea of female with about six simple recurved branches (Pl. I, Fig. H). All four blades of flagellum more or less dentate in both sexes (Pl. I, Figs. U and V). Palps robust (Pl. I, Fig. I). Trochanter with a distinct subconical heel; femur pedicellate, widest subbasally; tibia longer than femur and somewhat wider; chela of male obliquely truncate, hand with subparallel sides and nearly as long as femur; fingers much shorter than the hand. Palpal proportions: Male (holotype)—Trochanter slightly longer than fingers and 1.73 times as long as broad; femur shorter than carapace and subequal to posterior carapacal breadth, 2.85 times as long as broad; tibia 2.55 times as long as broad; chela broader than tibia and 3.05 times as long as broad. Female (allotype)— Trochanter 1.85 times as long as broad; femur 2.85 times as long as broad; tibia 2.4 times as long as broad; chela stouter than in male and with sides less nearly subparallel, 2.75 times as long as broad. Chela sexually differentiated, stouter in female than in male. Dental profile of female fingers not specialized; fixed finger evenly convex, movable finger

evenly concave especially distally (Pl. I, Fig. E); dental profile of fixed finger of male as in female except that the convexity is markedly accentuated; profile of movable finger with a marked basal and subterminal concavity and with a distinct median convexity (Pl. I, Fig. D). Chaetotaxy of chela as described for the genus and as illustrated (Pl. I, Figs. D and E). Fixed finger of male (holotype) with 29, movable finger with 36, marginal teeth; female (allotype) with 33 and 39 marginal teeth on fixed and movable fingers, respectively. Legs normal, relatively slender and as shown in Pl. I, Figs. K and J. Male genitalia as shown in Pl. I, Fig. B. Female genital area not significantly specialized.

Remarks.—This species is most closely related to *D. insularis* sp. nov., from which it has already been discriminated.

BIBLIOGRAPHY.

Beier, Max. 1932. Revision der Atemnidae (Pseudoscorpionidea). Zool. Jahrb. Abt. Syst. 62: 547–610; 22 Figs.

Chamberlin, Joseph Conrad. 1931. The Arachnid Order Chelonethida. Stanford University Press. pp. 1–284. Figs. 1–71.

Ellingsen, Edvard. 1906. Report on the Pseudoscorpions of the Guinea Coast (Africa). Collected by Leonardo Fea. Annali del Museo Civico di Storia Naturale de Genova, (series 3a), 2: 243–65; Pl. 4.

1912. The Pseudoscorpions of South Africa, Based on the Collections of the South African Museum, Cape Town. Annals of the South African Museum, 10: 75–128.

With, Carl. 1908. Remarks on the Chelonethi. Videnskabelige Meddelelser fra naturhistorisk Forening, Kjobenhavn. pp. 1–26; Pls. 1–2.

EXPLANATION OF PLATE.

Morphology of the Miratemninae.

Tullgrenius indicus sp. nov. A, male genitalia (somewhat distorted).

Diplotemnus insularis sp. nov. C, male genitalia (anterior genital operculum shown by the continuous light line delimiting the setose areas); G, male galea; R and S, vestitural setae from dorsum of fourth femur; T, flagellum of male.

Diplotemnus insolitus sp. nov. B, male genitalia, (opercular sclerites drawn superimposed upon the genital structures; plate X of genitalia omitted on right half of drawing); D, exteriolateral aspect of left male chela; E, exteriolateral aspect of right female chela; F, galea of male; H, galea of female; I, subventral aspect of right palp (male); J and K, first and fourth legs of male; L, exterior aspect of fixed finger of right female chelicera; M, tip of fixed finger of female chelicera showing lamina interior; N, vestitural seta from dorsum of fourth tibia and femur respectively; O, P, and Q, right half of carapace showing ocular detail and character of granulation; U, flagellum of female; V, flagellum of male; W, ventral aspect of right coxae.

PLATE I.

THE USE OF BLOWFLY LARVAE IN THE TREATMENT OF INFECTED WOUNDS.[1,2]

WILLIAM ROBINSON,
Washington, D. C.

The latest additions to the small group of beneficial insects are the common blowflies *Lucilia sericata* and *Phormia regina*. The larvae of these species have recently been elevated from the rank of humble scavengers to a position of respect in modern surgery. Under natural conditions these insects feed, as we know, upon dead and decaying animal tissue, and their associations are repulsive to the layman. In their new role, however, they are bred in hospital laboratories under strictly sanitary conditions and are used by the surgeon with the same care that he takes in operating.

The larvae are used in surgery in the treatment of infected wounds in which considerable dead tissue is present with the discharge of pus. They are especially effective in the treatment of the bone infection called osteomyelitis. These are deep-seated wounds, difficult to heal, which often cause long periods of disability and suffering. This disease, while not so common as some others, is still an important one. It can develop through such injuries as compound fractures, gunshot wounds, or deep cuts; and can also be carried to the bone by the blood stream from a distant point of infection, such as a boil or carbuncle. The writer has had the privilege of observing cases which have developed from each of these various injuries.

The disease is caused by certain pus-forming bacteria, as Streptococci and Staphylococci, which are commonly found on the skin and gain entrance to the body through such injuries as have been mentioned. Both children and adults may be affected.

Just a few words more about the disease and then we shall discuss the part played by blowfly larvae. In the treatment of chronic bone infection the procedure is to begin with a

[1]Contribution from the Division of Insects Affecting Man and Animals, Bureau of Entomology, U. S. Department of Agriculture.

[2]A Paper read at the annual meeting of the Entomological Society of America, Atlantic City, N. J., December 28–30, 1932.

surgical operation for the removal of the decaying bone. Ordinarily this is followed by a considerable period during which an effort is made to reduce the infection of the wound. The bone frequently continues to die, however, and sometimes requires additional operations for removal. In some cases seen by the writer several operations over a period of years have been required, and cases have been reported in which as many as 10 to 15 operations were performed.

On the other hand, when maggots have been used, a rather rapid improvement usually takes place. The quantity of dead tissue decreases; the offensive odor of the wound grows less and finally becomes unnoticeable; and the wound takes on a healthy appearance and begins to heal, although even with the maggot treatment a second operation is sometimes required.

The maggot method of treatment was introduced to surgery by the late Dr. Wm. S. Baer, of Johns Hopkins Medical School, about three years ago, (1, 3). In this short period the method has been used in probably three hundred hospitals throughout the United States and in Canada; and in the writer's visits to some of these hospitals he has found the surgeons who are using the maggot treatment to be gratified with the results obtained. Unfortunately, Dr. Baer did not live to see the widespread use of his method, for he died about two years ago.

In the medical profession the blowfly larvae are known solely as maggots, a name which apparently has come to stay, and which has not made the method any more attractive. At first, until they see the beneficial effects obtained, doctors, nurses, and patients usually regard the method as highly repugnant. Medicine has not lacked ingenuity in forming new terms to suit its needs, and it seems too bad, therefore, that the name "maggots," as commonly used in biology, has been accepted outright. Dr. Baer, who introduced the method, was once asked if the name did not detract from the use of the method. His reply was: "The treatment by any other name would smell as sweet!" (2). The term "larval therapy" was once suggested, but it did not take hold.

Maggots for surgical use are now reared in large numbers. Some hospitals have their own laboratory for this purpose. Others purchase the maggots ready for use, for there are at least two medical supply houses which make a business of producing maggots commercially. The production of maggots

in large quantities suitable for surgical use was a problem at first, but methods have now been devised which make it possible to breed larvae continuously the year around. The Bureau of Entomology extends to entomologists an invitation to visit its blowfly laboratory in Washington.

Blowflies are reared in colony cages and kept in incubators which maintain a temperature of about 80° F. and a relative humidity of between 40 to 60 per cent throughout the year. The flies are fed upon a mixture of diluted honey and yeast, or upon sugar or sliced banana. The cages are kept as clean as possible because sanitation is one of the essentials. A piece of fresh beef is placed in each cage daily for the flies to lay their eggs upon. A colony of 100 flies can lay at least 1,000 eggs daily; and a small laboratory can easily take care of 10 colonies. One firm which produces maggots commercially has 200 cages which are kept in a large air-conditioned room and under the best of sanitary conditions. Blowflies continue to lay eggs well for about three weeks, after which they are destroyed and replaced by fresh, young colonies reared for that purpose. Within 24 hours the eggs hatch and the larvae feed for about seven days at laboratory temperatures. The feeding period is shorter in the wound because the temperature is higher.

As they occur in nature, maggots would not, of course, be suitable for use in human wounds; nor even when produced under the most sanitary conditions possible in the laboratory, alone. They must be sterilized, for the introduction of disease organisms into the wound must be avoided. Sterilization can not be done in the maggot stage; because the disinfectant can not reach the alimentary tract, which of course would be contaminated. Therefore the maggots must be reared free from contamination. This requires the aseptic technic of bacteriology throughout the process, beginning with the eggs. The eggs are sterilized generally with a mercuric chloride or a formalin solution (3, 4, 5, 6, 7, 12). They are then placed upon sterilized food in glass containers. In this way the larvae feed under sterile conditions and never have access to contamination while being cultured. As an additional precaution, bacteriological tests for sterility are made upon each lot of maggots, and any lot which shows contamination is discarded. When the maggots have made about two days' growth they have reached the size suitable for use in wounds. For anyone

interested in the culture of sterile maggots, several articles have been published in the medical literature (3, 4, 5, 7, 9, 11), and two others (6, 8) are probably more available to biologists.

You may be interested, now, in how the maggots are used, and what the patients think of this treatment. The consent of the patient is, of course, obtained before treatment. He is usually very willing, however, to accept any treatment which will bring relief and from which a cure may be expected. Whenever the disease is deep-seated, as in bone infections, a surgical operation is first performed to remove dead tissue and to open up the wound for drainage of pus. The wound thus opened also provides a suitable environment for the maggots, as they are more or less surface feeders and will not penetrate deeply into a sinus. After the operation, the wound is packed with gauze and the patient is allowed to rest for one or two days until bleeding has ceased. Next the packing is removed and the wound is ready for the first implantation of maggots.

The maggots are brought to the bedside in sterile glass containers which usually hold from 700 to 1,000 maggots about one-quarter of an inch long. They are whitish, clean-looking, and not in themselves especially repellent. The number used varies considerably with the size and location of the wound, but would probably be between 200 and 600. The maggots are placed in the wound aseptically and the wound is covered to retain them. A satisfactory method (4) is to use a piece of gauze as a covering, fastening it to the skin with a liquid adhesive. The maggots feed upon the dead tissue and the pus within the wound, and in three to four days become full-grown. They then cease feeding and are of no further use in the wound. They are easily removed by washing out the wound with sterile salt solution. A fresh lot of maggots may be placed in the wound at once, or the patient may be given a day to rest between implantations. The number of implantations varies, of course, with each case. The use of maggots may be discontinued, however, after three or four weeks, or the treatment may last for months.

There is no danger of parasitism or internal injuries from the use of the species *Lucilia sericata* or *Phormia regina*. In nature, the maggots leave their food when full-grown and migrate to a suitably dry and dark place for pupation. Therefore, when used in human wounds the larvae will not enter the

body tissues. There is one species of blowfly called the screw worm (*Cochliomyia macellaria*) which can not be used because it does not discriminate between dead and living tissues, and would thus cause serious injury within the wound. The species recommended feed only upon the devitalized tissues and are quite safe to use.

Usually the patient soon becomes accustomed to the maggot treatment. At first the larvae sometimes cause sharp, intermittent pain by their feeding and their movements within the wound. The pain decreases, however, as new tissue grows. The watery discharge from the wound, which occurs when maggots are used, sometimes irritates the skin as it drains from the wound. As treatment progresses, however, the annoyances peculiar to this method gradually become less pronounced, or the patients grow more reconciled to them. In general, sufferers from chronic infected wounds are willing to have the maggot treatment continued when they see how satisfactorily the wound is healing. They take an interest in the treatment and like to observe the dressings being changed and the maggots put in.

As to the functions of maggots in hastening healing of the wound; the indications are that the removal of dead tissue and pus from the wound by maggots in their feeding is one of the important features. Maggots penetrate to all parts of the wound suitably opened up by the surgeon, and feed continually throughout their growing period. The quantity of material removed by a single implantation of maggots is surprisingly large (10).

At the beginning of the treatment the wound is highly infected with pus-forming and other pathogenic bacteria which must be eliminated before healing can take place. Among the methods of removing infection, without the use of maggots, is that of applying chemical disinfectants as irrigations or as saturated packs. This tends to irritate the tissues and has not been altogether satisfactory. In another method a plaster cast is formed both in and around the wound, and the entire arm or leg, as the case may be, is kept motionless for a fairly long period. In this case the bacteria do tend to diminish, but it is a slow process; and the wound develops a most offensive odor, so much so that the patient can not be kept in the same room with others.

Under the maggot treatment, however, bacteriological counts taken at intervals commonly show that the number of bacteria in the wound decreases comparatively rapidly, without any ill effect upon the wound and certainly without the offensive odor.

Maggots have been found to assist in the disinfection of the wound in the following way (10): In the first place, the removal of the dead tissue from the wound by maggots makes conditions less favorable for the development and increase of bacteria. Secondly, the excessive discharge which occurs in the wound carries away large numbers of bacteria as it drains off. In the third place, maggots take up large numbers of bacteria with their food, and as the bacteria pass along the alimentary canal they become digested and destroyed. Dissections and cultures of portions of the canal have shown that the stomach of the maggot is highly infected but that the intestine is free from bacteria.

There is just one more aspect of the maggot treatment which should be mentioned. The operation for removal of dead bone leaves a comparatively deep and wide wound, and as healing progresses it is desirable that the wound fill in with healthy tissue. In treatment without maggots, if the wound heals it frequently does not fill up to the surface, which leaves a weakened bone structure and an unsightly depression. Under the maggot treatment one of the outstanding features is the abundant growth of granulation tissue within the wound. It sometimes develops so rapidly along the upper surfaces that it has to be cut away or the wound held open with retractors; as, of course, the wound must heal and fill in from the bottom upward.

The rapidity with which this method of treating infected wounds has spread is probably sufficient testimony to the merits of the maggot treatment.

REFERENCES.

1. **Baer, Wm. S.** 1929. Viable antiseptic in chronic osteomyelitis. Proc. Interstate Postgrad. Med. Assem. N. A., Detroit, Mich., pp. 370–2.
2. **Baer, Wm. S.** 1930. The treatment and cure of the disease known as osteomyelitis. Hearings before Committee on World War Vet. Legislation; House of Rep., 71st Congress, 2nd Session, Washington, D. C., pp. 24.
3. **Baer, Wm. S.** 1931. The treatment of chronic osteomyelitis with the maggot (larva of the blowfly). Jr. Bone Joint Surg. 13: 438–475.
4. **Buchman, J.** and **Blair, J. E.** 1932. Maggots and their use in the treatment of chronic osteomyelitis. Surg. Gyn. Obst. 55: 177–190.

5. **Child, F. S.,** and **Roberts, E. F.** 1931. The treatment of chronic osteomyelitis with live maggots. N. Y. State Jr. Med. 31: 937–943.
6. **Miller, D. F., Doan, C. A.,** and **Wilson, E. H.** 1932. The treatment of osteomyelitis (infection of bone) with fly larvae. Ohio Jr. Sc. 32: 1–9.
7. **Murdoch, F. F.,** and **Smart, T. L.** 1931. A method of producing sterile blowfly larvae for surgical use. U. S. Naval Med. Bull. 29: 406–417.
8. **Robinson, Wm.** 1932. The rearing of blowflies and the culture of sterile maggots for use in osteomyelitis. U. S. Dept. Agr., Bur. Ent. Multi. Circ. E-296.
9. **Robinson, Wm.** 1933. Surgical maggots in the treatment of infected wounds; culture of sterile maggots. Jr. Lab. Clin. Med. 18: 406–412.
10. **Robinson, Wm.,** and **Norwood, V. H.** 1933. The role of surgical maggots in the disinfection of osteomyelitis and other infected wounds. Jr. Bone Joint Surg. 15: 409-412.
11. **Weil, G. C., Henry, J. P., Nettrour, S.,** and **Sweadner, R.** 1931. The cultivation and sterilization of the fly larva or maggot. W. Va. Med. Jr. 27: 458–461.
12. **White, G. F.** 1931. Production of sterile maggots for surgical use. Abst., Jr. Parasitol. 18: 133.

LEHRBUCH DER ENTOMOLOGIE, by PROFESSOR DR. HERMANN WEBER. Pages i–xii, 1–726 with 555 text figures. 1933. Published by Gustav Fischer, Jena. Unbound, Rmk 36, bound, Rmk 38.

Professor Weber is in the Zoologisches Institut of the Technischen Hochschule of the free city of Danzig on the Baltic coast of the Polish Correador where political changes may come over night. In entomology he rates as one of the world's leading morphologists. His wonderful ability as an artist makes his work very impressive while his technique in the thorough correlation of musculature and skeletal parts makes his work sound. While he has written general papers on the thorax, and other general features, his main studies have been on the morphology of the hemipteroid insects. These were summarized in his "Biologie der Hemipteren."

The present volume is divided into seven long but thoroughly organized chapters with numerous subheads. The chapter headings, translated, are as follows: Chapter I, Skeleton and Musculature; II, Nervous System and Sense Organs; III, Nervous Functions; IV, The Organs of Metabolism; V, Reproduction and Development, (embryonic and postembryonic); VI, Relations to the Environment; VII, Review of the System (Systematic). This body of the work is followed by a "Literature List" of sixteen pages which is of value to American workers because it is a key to continental literature. It is organized by chapter headings and subheads, but is set solid and omits titles except for books. To judge the value of any item, this would have to be looked up or checked in some other bibliography. There are twenty-nine pages of index.

The value of the work is in its presentation of the latest in the morphology and histology of insects. It is the most complete work of this nature since the appearance of Gli Insetti by Berlese in 1909. The first chapter (250 pages) which is one-third of the volume, covers the field in which the author has worked so successfully and is thus the most valuable part of the work. Chapters II and III (110 pages) discuss the nervous system from the same point of view as that found in Hanström's "Vergleichende Anatomie des Nervensystems der Wirbellosen Tiere," using material from the same sources. Chapters IV to VII are each shorter, but present the problems discussed in a well organized and well illustrated manner. Altogether it is an outstanding work and will be a necessity in the library of all students of insect morphology. We are impressed with the amount and high quality of Professor Weber's production in his favorite field.—C. H. K.

NOTES ON SOME SOUTH AMERICAN MOSQUITOES.*

NELSON C. DAVIS,
(From the Yellow Fever Laboratory of the International Health Division of The Rockefeller Foundation, Bahia, Brazil.)

Anopheles (Stethomyia) thomasi Shannon (1, 2).

Larvae of *Anopheles* (*Stethomyia*) *thomasi* Shannon, from which both males and females were reared, were taken in August, 1932, at the type locality, Rio Cururipe, near São Salvador, Bahia, Brazil. Breeding occurred along the marshy edges of a rivulet in the woods. Plate I shows a few features of the larva, which is very similar to that of *A.* (*Stethomyia*) *kompi* Edw., described as *Stethomyia nimba* by Shannon and Davis (3). The palmate hairs are rudimentary, delicate, and difficult to see in both species. In our specimens the pecten of *kompi* has more numerous teeth, and these are more heavily fringed than in *thomasi*. However, the identification can be made more easily by examining the anterior submedian thoracic groups of hairs. In *kompi* the inner hair of this group is relatively short and has usually six or more branches or filaments rising as a terminal tuft from a thicker basal stem. In *thomasi* the corresponding hair is longer and usually forked at the extremity; it may also be simple, without branches; or, rarely it may have three short branches at the tip. This difference between *kompi* and *thomasi* is shown in Plate I, figures *e* and *f*.

Anopheles maculipes (Theobald) (**Arribalzagia pseudomaculipes** Peryassú).

In April, 1932, specimens of *Anopheles maculipes* were found in collections sent to the laboratory by Dr. Fred L. Soper from the Valle do Chanaan, state of Espirito Santo, Brazil. The species was associated in the collections with another of the *Arribalzagia* group, *A. intermedius*, as well as with various species of the subgenus *Nyssorhynchus*. *A. maculipes* and *A. intermedius* range together through the lowlands of the state of Rio de Janeiro; *A. intermedius* extends northward as far as the Amazon Valley and is fairly numerous in some

*The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Division of The Rockefeller Foundation.

localities, but *A. maculipes* appears to have a much more limited distribution. The latter species has not been found by us in the state of Bahia, although collections have been made as far south as Caravellas near the border of Espirito Santo.

Anopheles (Nyssorhynchus) rondoni (Neiva and Pinto).

The species *Anopheles rondoni* was first found in 1922, in the state of Matto Grosso, Brazil, by Neiva and Pinto (4), who also observed the species at Rincão in the state of São Paulo, Brazil (Caesar Pinto, 5). Petrocchi in 1924 obtained adult specimens in Santa Clara, Argentina. In August, 1925, larvae from which adults were reared were taken by the writer at Ledesma, province of Jujuy, Argentina. In 1928 Davis and Shannon (6) described the habits of *A. rondoni*, as observed at Ledesma. By rearing adults from eggs laid by captured females, it was shown that the species breeds true; a black ring occurred on the third hind tarsal of all mosquitoes of the second generation.

Anopheles rondoni cannot be considered a mere variety of *A. tarsimaculatus* or of *A. strodei*. Caesar Pinto (5) has given a figure of the male terminalia of *A. rondoni* and has pointed out that they cannot be distinguished with certainty from those of *strodei*. Root (7) makes the following statement concerning *A. rondoni:* "Yet study of specimens of the larva and male hypopygium . . . . has so far failed to reveal any definite differences from the corresponding structures of *strodei*." As a general statement this is quite correct, but between the larvae of the two species there seem to be certain minor differences of degree, if not of kind, which are worth recording.

The inner anterior clypeal hairs of the *rondoni* larva rise closer together than those of the *tarsimaculatus* larva, approaching the condition in *argyritarsis*. The outer anterior clypeal hairs are about three-fourths the length of the inner ones; both pairs of clypeals are weakly branched. The anterior submedian thoracic groups of hairs are set in fairly close proximity, although the leaflets of the inner hairs seldom touch. This condition is similar to that in *albitarsis* rather than to that in *tarsimaculatus*. Well developed palmate hairs are found posteriorly on the thorax and on the first seven abdominal segments, as in *albitarsis* and *tarsimaculatus*.

All the characteristics mentioned are common to fourth stage larvae of both *rondoni* and *strodei*. However, the latter species appears to have a greater development of elements, both in size and in complexity. Figures *c* and *f* of Plate II show the anterior submedian thoracic group of hairs in *rondoni* and in *strodei*, drawn to the same scale from balsam mounts. In addition to a difference in size, the inner hair of *strodei* has more leaflets. As pointed out by Root (8), the number of leaflets in *strodei* varies from sixteen to nineteen. In our specimens of *rondoni* the number of leaflets varies from eleven to fourteen. In a similar manner the abdominal palmate hairs differ in size and in number of leaflets (figures *d* and *g*, drawn from fourth segments of *rondoni* and *strodei*, respectively). In *rondoni* the number of leaflets is twenty to twenty-four, in *strodei* it is twenty-six to thirty. In addition to the palmates, various other abdominal hairs show a greater development in *strodei* than in *rondoni*. The pecten in *strodei* has more numerous teeth and usually a longer uninterrupted row of short teeth. These are all minor differences which should be checked in larger series of larvae than are available to the writer at present.

In Plate II the larva of *Q. rondoni* is shown with an accessory hair on the seventh segment; this seems to be inconstantly present. In many larvae of the *Nyssorhynchus* group the sixth abdominal segment lacks antepalmate hairs. In the larva shown in Plate II these hairs are present, but shifted to a medio-posterior position relative to the palmates. This cannot be considered a diagnostic character of the species. The larva drawn in Plate II was hatched from an egg laid by an identified *A. rondoni* captured in Ledesma, Argentina.

SPECIES VARIATION IN THE SUBGENUS NYSSORHYNCHUS.

In a previous publication (9) emphasis was placed on the variability of markings on adult mosquitoes of the *Nyssorhynchus* group of *Anopheles*. Variations also occur in larval structures. In the course of identifying large numbers of larvae, anomalous and atypical forms are usually encountered. Such atypical larvae frequently pupate and produce typical adults of one species or another. There is no evidence of hybridization; at least one set of characters dominates in the adult which emerges. In Plate III are represented the head and anterior part of the thorax of an atypical *tarsimaculatus* and of an

atypical *albitarsis* larva (drawings made from larval skins) together with normal representatives of the two species. The anomalous condition in each case is confined to the clypeal hairs. Both anterior pairs in the atypical *tarsimaculatus* larva are forked and branched to an unusual degree. The adult male which was bred from this larva appeared to have normal markings and hypopygeal structures. The atypical *albitarsis* larva has its internal clypeal hairs rising close together, as in the *strodei* larva. The adult female bred from this larva appeared to be normal in all respects. All four larvae figured in Plate III came from the neighborhood of São Salvador, Bahia, Brazil.

Mansonia (Rhynchotaenia) chrysonotum (Peryassú) (10).

As pointed out by da Costa Lima (11) and by Shannon (2) this species should not be confused with *Mansonia* (*Mansonia*) *amazonensis* as was done by Dyar (12). In Brazil *M. chrysonotum* is now known to have a wide distribution. Since Peryassú's original paper in Portugese is not readily available, translated extracts are given below from his description of *Taeniorhynchus chrysonotum*.

Female.—Slight augmentation. General color dark. Proboscis straight, dark, with a light cream-colored ring toward the middle, slightly nearer the apex; base of the labellae with a narrow, light cream-colored ring. Occiput golden. Anterior half of the mesonotum golden. Abdomen dark, with white lateral spots basally on the segments; spots show many golden hairs. Legs dark and spinose; joints light, with basal and apical rings of light cream-color. Wings dark brown, with a small cream-colored spot at the base next to the costa.

Greater magnification. Mesonotum dark, densely clothed with golden and dark scales of two forms, very narrow falciform and broader falciform. The golden scales form three wide stripes, median and parallel, that extend from the anterior part of the mesonotum to a little beyond its middle; on the posterior half there are many golden scales in patches, some in continuation of the anterior stripes, others beyond the root of the wings. The dark scales cover the lateral and posterior parts of the mesonotum; they are interspersed with many dark chestnut-colored hairs of various sizes, principally on the sides and next to the wing bases. When scales are rubbed off there are noted two dark chestnut, median, longitudinal lines.

Male.—Male proboscis as in the female. Palpi a little longer than the proboscis, with four basal white rings; clothed with dark brown scales and with many long hairs on the apices of the antepenultimate, penultimate, and last segments, the hairs being the longest and densest

on the penultimate. Antennae much shorter than the proboscis, very plumose, brown in the basal half and dark brown in the apical, with the segments much lighter than the brown articulations. Thorax as in the female, but the longitudinal golden stripes extend to the median lobe of the scutellum, although less rich in scales. Abdomen as in the female, but more hairy. Genital organs (hypopygium) prominent, very hairy, with strong, brown claspers. Wings as in the female, but shorter than the abdomen. Legs as in the female, but more spinose. Claws . . . etc.

Captured in March and April.

Valley of the Rio Doce, state of Espirito Santo, and lowlands of the state of Rio de Janeiro.

Peryassú's description of the male and female adults is very full. However, he does not mention the microscopic appearance of the male genitalia. The writer was fortunate enough to secure two males at Caravellas, Bahia, in January, 1931, while making an evening capture with animal bait. In April, 1932, three additional males were caught near the city of São Salvador, also during an evening capture. The male terminalia are figured in Plate IV. The general features are those of the subgenus *Rhynchotaenia* (see Plate V, terminalia of *M. justamansonia*). A distinguishing character is the dense patch of hairs on the inner aspect of the side-piece, slightly nearer the base than the apex.

Mansonia (Rhynchotaenia) justamansonia (Chagas).

Shannon (2) has mentioned the swarming of *Mansonia justamansonia* at twilight. He captured a few males on the outskirts of São Salvador, Bahia. In April, 1932, a series of night captures was made in the same general region where males had been caught previously. A horse was used to attract female mosquitoes. During a period of about one-half hour just after nightfall males hovered over the animal, especially over its head, in wait for the females. The swarm could be seen readily against the sky, or in the rays of a flashlight. Various specimens were caught with a net. Table I, page 282, shows the relative prevalence at these captures of males and females of four species of the subgenus *Rhynchotaenia*.

It will be noted that in spite of the presence of considerable numbers of female *M. fasciolata*, no males of this species were taken. No males of *albicosta* and only three of *chrysonotum* were captured. Whether at some other season or hour the

males of these species might be attracted has not yet been determined.

Dyar (12) has given a drawing of the male terminalia of *M. justamansonia*, but on such a small scale that details are lacking. Our figures (Plate V) show that the basal lobe of the side-piece bears two closely approximated spines, not one, as recorded by Dyar in both description and drawing. However, these spines, although slightly separable at their base, are adherent throughout much of their length.

TABLE I.

Results of Night Captures of *Mansonia* Mosquitoes Near São Salvador, Bahia.*

Date	Sex	*M. fasciolata*	*M. justa-mansonia*	*M. chrysonotum*	*M. albicosta*
April 8, 1932....	Female....	56	42	7	....
	Male.....	....	18	3	....
April 12.....	Female....	85	51	31	31
	Male.....	....	1	....	....
April 15.....	Female....	28	40	10	5
	Male.....	....	47†	....	....

*A horse was used as bait.
†Two taken after alighting on horse.

Aedes (Ochlerotatus) oligopistus Dyar.

In August, 1932, in a collection of adult mosquitoes taken during daylight hours at Rio Cururipe near São Salvador, there was found a male *Aedes oligopistus*, a drawing of whose terminalia is shown in Plate VI, figure *c*. Although the specimen was somewhat rubbed, as nearly as can be determined it conforms to the description of this species. The terminalia also correspond to the figure given by Dyar (12). Many *Aedes hastatus*, both males and females, were found in the same collection.

The latter species has been recorded by Shannon (2) from Bahia, Brazil. The larvae have been found associated with those of *Ae. serratus* in pools and marshy areas after the earliest heavy rains of the season. They are recognized at a glance by the long, filamentous anal gills. It is presumed that a detailed description of all stages will be given by Shannon in

the near future. A drawing of the male terminalia is given in Plate VI, figure *a*, for comparison with that of the related species *Ae. oligopistus*.

Aedes hastatus is known from Panama and Costa Rica. *Aedes oligopistus* was described from specimens taken in Trinidad; the one captured near São Salvador is the only one known to the writer to have come from the mainland of South America.

REFERENCES.

1. **Shannon, R. C.** Correction. Proc. Ent. Soc. Wash. 35: 58, 1933.
2. **Shannon, Raymond C.** On the classification of Brazilian Culicidae with special reference to those capable of harboring the yellow fever virus. Proc. Ent. Soc. Wash. 1931, 33, 125.
3. **Shannon, Raymond C.,** and **Nelson C. Davis.** Observations on the Anophelini (Culicidae) of Bahia, Brazil. Ann. Ent. Soc. Amer., 1930, 23, 467.
4. **Neiva, A.,** and **C. Pinto.** Contribuiçao para o conhecimento dos Anophelinos do Estado do Matto Grosso com a descripçao de uma nova especie, *Cellia rondoni*. Brasil-Medico, 1932, 36, Part 2, 321.
5. **Pinto, Cesar.** Arthrópodes parasitos e transmissores de doenças. Bibliotheca Scientifica Brasileira, Published by Pimento de Mella & Cia., Rio de Janeiro, 1930, II, 556 pages.
6. **Davis, Nelson C.,** and **Raymond C. Shannon.** The habits of *Anopheles rondoni* in the Argentine Republic. Amer. Jour. Hyg., 1928, 8, 448.
7. **Root, Francis Metcalf.** The present status of our knowledge of the Nyssorhynchus group of anopheline mosquitoes. Trans. of Fourth International Congress of Entomology, Ithaca, August, 1928, 2, 316, 1929.
8. **Root, Francis Metcalf.** Studies on Brazilian mosquitoes. I. The anophelines of the Nyssorhynchus group. Amer. Jour. Hyg., 1926, 6, 684.
9. **Davis, Nelson C.** A consideration of variability in the Nyssorhynchus group of the genus Anopheles. Amer. Jour. Hyg., 1928, 8, 539.
10. **Peryassu, Antonio Goncalves.** Uma nova especie de Culicineo Brasileiro, *Taeniorhynchus chrysonotum* Peryassú (n. esp.). *A. Folha Medica*. 1922, 3, 117; 1923, 4, 76.
11. **da Costa Lima, A.** Sobre algumas especies de Mansonia encontradas no Brasil. Memo. do Instituto Oswaldo Cruz, (Suppl.) No. 12, (December 31), 1929, 297.
12. **Dyar, Harrison G.** The mosquitoes of the Americas. Published by Carnegie Institution of Washington, 1928.

EXPLANATION OF PLATES.

The magnifications stated below are slightly less than twice those shown on the plates, 8.25 ÷ 4.25.

PLATE I.

a. Head and thorax of *Anopheles thomasi* larva, × 70. b. Posterior extremity of *A. thomasi* larva, × 70. c. Pecten of *A. thomasi*, × 300. d. Pecten of *A. kompi*, × 300. e. Anterior submedian thoracic group of hairs, *A. thomasi*, × 115. f. Anterior submedian thoracic group of hairs, *A. kompi*, × 115. g. Palmate hair, fourth abdominal segment, *A. thomasi*, × 500.

PLATE II.

a. Larva of *Anopheles rondoni* (anal segment separate), × 45. b. Anterior part of head, showing clypeal hairs, × 215. c. Anterior submedian thoracic group of hairs, *A. rondoni*, × 115. d. Palmate hair, fourth abdominal segment, *A. rondoni*, × 215. e. Pecten, *A. rondoni*, × 300. f. Anterior submedian thoracic group of hairs, *A. strodei*, × 115. g. Palmate hair, fourth abdominal segment, *A. strodei*, × 215.

PLATE III.

a. Head and anterior part of thorax of normal *A. albitarsis larva*, × 50. b. Head and anterior part of thorax of atypical *A. albitarsis* larva, × 50. c. Head and anterior part of thorax of normal *A. tarsimaculatus* larva, × 50. d. Head and anterior part of thorax of atypical *A. tarsimaculatus* larva, × 50.

PLATE IV.

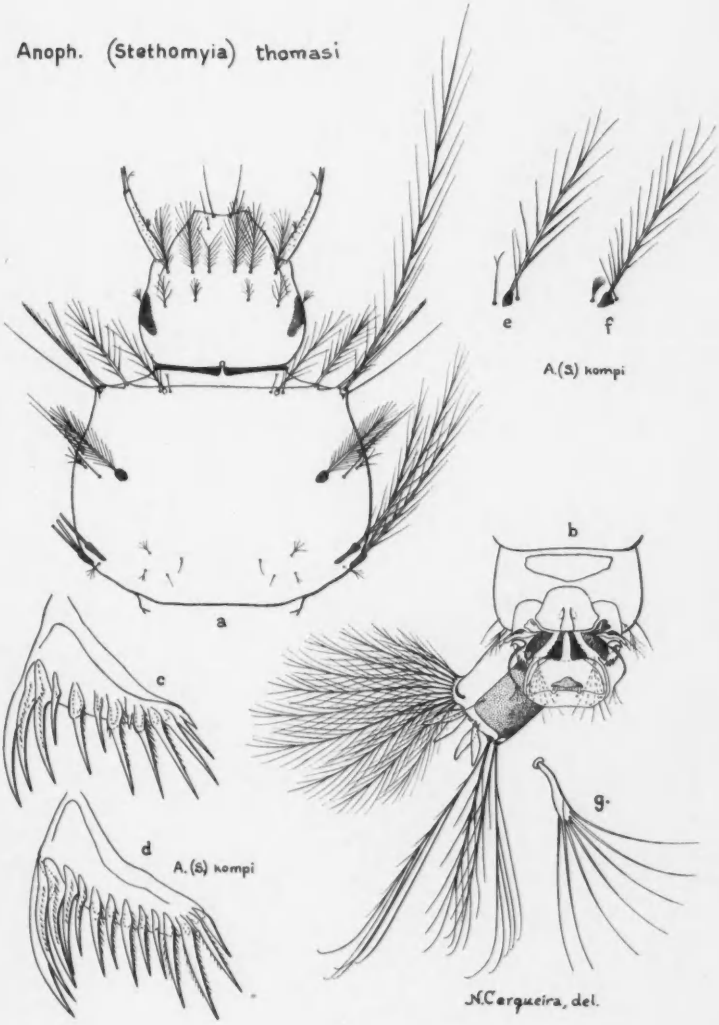
a. Terminalia of male *Mansonia chrysonotum*, × 215. b. Ninth tergites of *Mansonia chrysonotum*, × 215. c. Basal lobe of *Mansonia chrysonotum*, × 300.

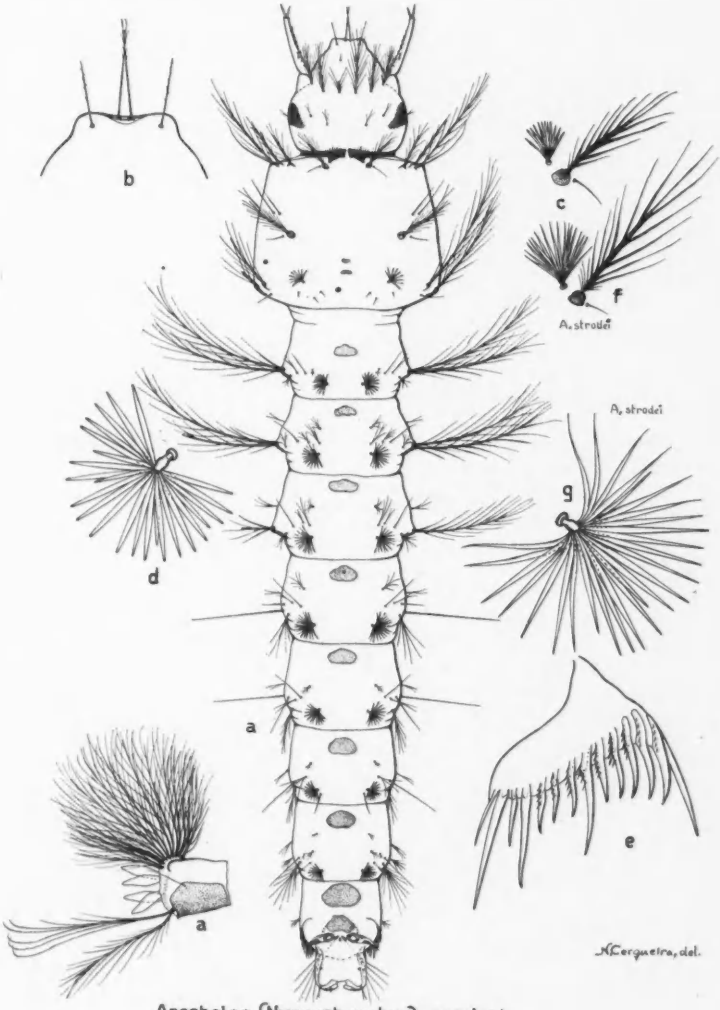
PLATE V.

a. Terminalia of male *Mansonia justamansonia*, × 155. b. Ninth tergites of *Mansonia justamansonia*, × 215. c. Basal lobe of *Mansonia justamansonia*, × 300.

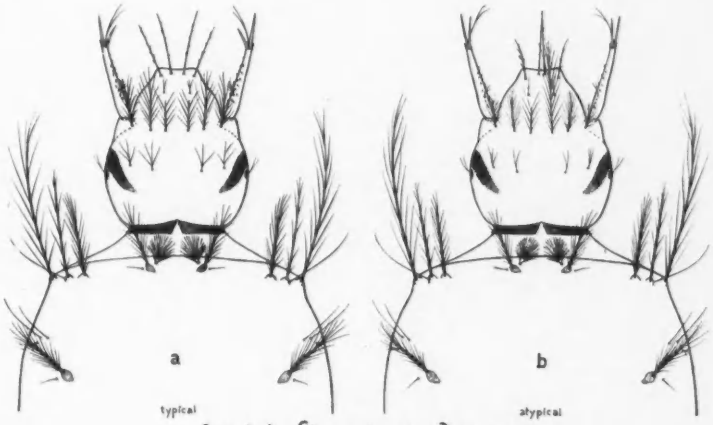
PLATE VI.

a. Terminalia of male *Aedes hastatus*, × 155. b. Ninth tergites of *Aedes hastatus*, × 215. c. Terminalia of male *Aedes oligopistus*, × 215. d. Ninth tergites of *Aedes oligopistus*, × 215.

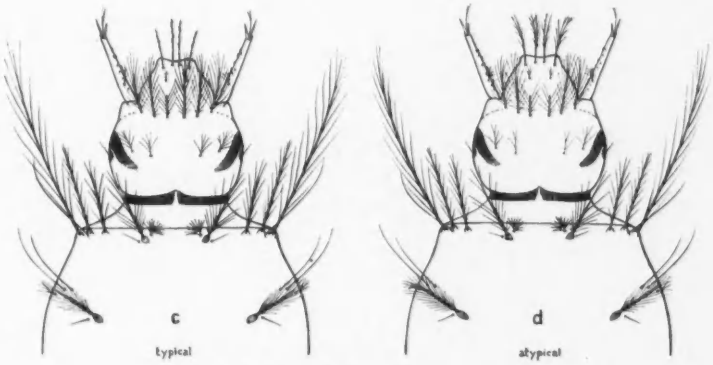

Anoph. (Stethomyia) thomasi
a
b
c
d
A. (S.) kompi
e
f
A. (S.) kompi
g.
N.C. orqueira, del.



Anopheles (Nyssorhynchus) rondoni



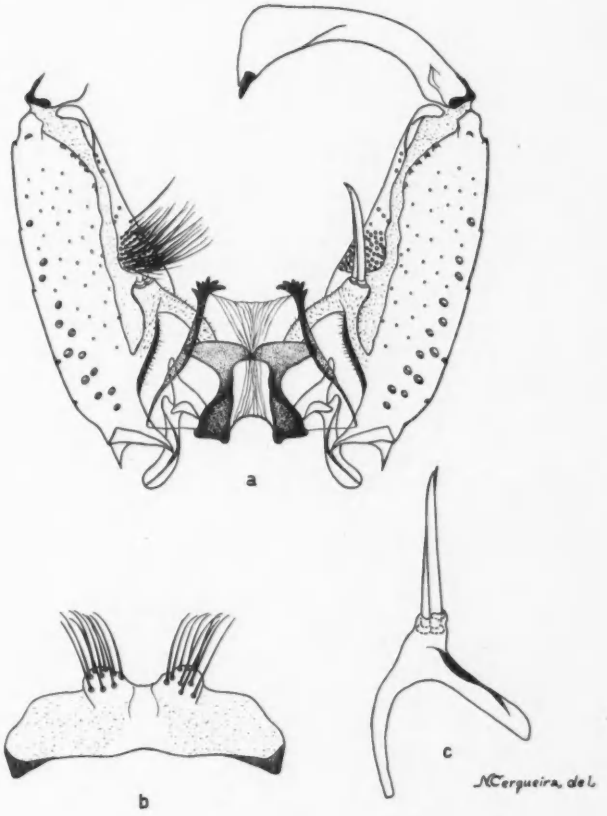
Anopheles (Nyssorhynchus) albitarsis



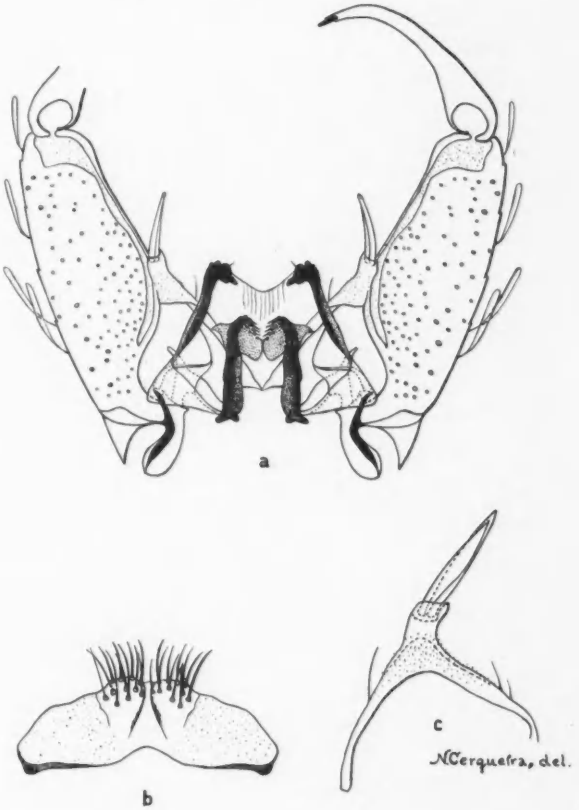
Anopheles (Nyssorhynchus) tarsimaculatus

H. Lourenço, del.

Mansonia chrysonotum



Mansonia justamansonia



a
b
Aëdes hastatus
c
d
Aëdes oligopistus
NCerqueira del.

THE APPLICATION OF ARTIFICIALLY PROLONGED HIBERNATION OF PARASITES TO LIBERATION TECHNIQUE.

W. A. Baker and K. D. Arbuthnot,
Bureau of Entomology, U. S. Department of Agriculture.

When a noxious insect has become established in a previously uninfested area and the introduction of its parasitic enemies is undertaken, workers are confronted with numerous problems involving relationships between parasites and hosts. One problem sometimes encountered is a lack of synchronization in the development of the parasites which are being introduced and that of their hosts. A problem of this type has been experienced with *Microgaster tibialis* Nees and *Eulimneria crassifemur* Thoms., brought from Europe for colonization in the North Central States, where their host, *Pyrausta nubilalis* Hbn., has but one generation each year.

Several workers (*2*, *3*, *4*) (Italic numbers in parentheses refer to literature cited) of the U. S. Bureau of Entomology in Europe have studied the relationship of spring emergence of these parasites to the presence of hosts suitable for parasitization. Thompson and Parker (*2*) state: "*M. tibialis* hibernates as a prepupal larva in its cocoon, from which it emerges as an adult toward the end of April or early in May in northern France. From the time the parasite issues to the period when young larvae of the host are available on the *Artemisia* plants a considerable period elapses, comprising sometimes over two months." Concerning *Eulimneria crassifemur* they state: "When the late winter and early spring are mild the hibernating individuals tend to emerge very early in the year, and even in normal years they issue long before any larvae of the corn borer are available. For example, in Auch (southwestern France) in 1921 the great majority of the parasites had emerged by the middle of April, but no host larvae were present in the fields until after the end of June."

When overwintering cocoons, collected in the European areas where the reactions quoted heretofore occur, have been exposed to out-of-door conditions after receipt at the Monroe, Mich., laboratory, emergence has occurred at approximately

the same time as it does in the field in Europe. For example, in 1930, *M. tibialis* placed out of doors February 1 produced adults from May 1 to May 20. In 1931, *E. crassifemur* placed out of doors February 9 produced adults from May 15 to May 25. Borers suitable for parasitization by these species were not present in the field until approximately the middle of July.

Each year, from 1925 in the case of *M. tibialis* and from 1926 in the case of *E. crassifemur* (*1, Tables 4, 5 and 6, pp. 25 to 27*), colonies have been liberated at this time (May 1 to May 25). The details of these liberations are discussed later in this paper. Collections of borers in the immediate vicinity of colony sites have been made since 1928 for the purpose of determining the parasite status, and in this period hundreds of thousands of borers, collected for other purposes in the more heavily infested areas, have been under observation. From these ample sources the recoveries of these two species were extremely meager and have furnished no positive data to indicate a successful initial establishment of either species.

In order to test various possible means for synchronizing liberation of these parasites with presence in the field of corn borers in stages suitable for their attack, experiments at Monroe, Mich., with *M. tibialis* were begun in 1928, and with *E. crassifemur* in 1929. The purpose was to develop a method by means of which adult parasites would be available for liberation at approximately the middle of July instead of the normal emergence date of these species, which is approximately the middle of May.

The method developed and successfully utilized for securing adult parasites at the desired time consists of the storage of cocoons from time of receipt until the first of July at temperature 35° F. and relative humidity 90 to 100 per cent, after which the parasites are permitted to emerge from them at temperature 80° F. and humidity 85 per cent. By this method 85 to 90 per cent of the larvae of *E. crassifemur* (which have not cast their meconium) and of the prepupae of *M. tibialis* which have been retained in cold storage become available for liberation as adults when their host in the field is in stages which they attack. With each parasite, the stages indicated must be utilized for successful manipulation. This method is in reality an artificial prolongation of the normal hibernating period of the parasites, from May until July, and results in the occurrence

of adults at a time in marked contrast with that of their natural seasonal occurrence in Europe or in this area of the United States.

At the time of inception of this work it was thought improbable that the seasonal rhythm of these parasites would be affected by the application of a method that would accomplish the desired results. This premise was substantiated, in the case of *M. tibialis*, by individuals collected in the fields of this area in the falls of 1930 and 1931 and in the spring of 1931. These individuals resulted from parasitization by *M. tibialis* liberated in July, 1930, and they responded to subsequent environmental conditions in the same manner as this species does when originating in areas in Europe having a single generation of *Pyrausta nubilalis*. The artificial conditions thus imposed on these two parasites can not influence their effectiveness under field conditions, since, after initial establishment is thus secured, the seasonal rhythm of the parasite immediately responds to natural influences, without respect to prior artificial treatment.

For manipulation of *M. tibialis*, details of handling had been determined prior to 1930, and subsequent liberations were made in July of each year, except at one colony site, Monroe County, Michigan, where the parasites were liberated in May, as indicated in Table I. The numbers of individuals liberated, listed by years and localities, are shown in this table.

As has been stated before, recoveries from the early (May) liberations were unsatisfactory, and no specimen of *M. tibialis* has been recovered in Monroe County, Mich. No reason was apparent for the failure of this species to appear in Erie County, Pennsylvania, in 1930, since, in spite of a sharp decline in the borer infestation, considerable numbers of hosts were present. In Huron County, Ohio, borers were extremely scarce and this condition may have been the reason for the non-recovery of the parasite (due possibly to the inability of the parasite to find its host or the inadequacy of the borer sample collected). In 1931 and 1932 the fall recovery collections made in areas in which the parasites had been liberated and recovered the previous seasons (1930 or 1931) failed in every instance to show this parasite present except in those localities where current synchronized liberations were also made. This indicates that permanent establishment has not occurred. The collections

made at the same time (falls of 1931 and 1932), in areas where current synchronized liberations were made, resulted in finding cocoons of *M. tibialis* in all localities except Steuben County, Indiana, in 1931.

TABLE I.

Microgaster tibialis Liberated in the North Central States.

(Those shown in italics were liberated when hosts were available for parasite attack.)

State	County	1925	1926	1927	1928	1929	1930	1931	1932
Michigan..	Monroe....	.....	.....	11,906	24,508[2]	3,562[2]	2,075[2]	1,530[2]	1,504[2]
	St. Clair...	.....	.....	5,711	11,395[2]	2,585[2]	*4,994*[1]	*1,962*[1]	[2]
	Oakland....	.....	.....	.....	.....	1,970[2]	*1,989*[1]	[2]	[2]
	Washtenaw	.....	.....	.....	.....	1,765[2]	[2]	[2]	[2]
	Lenawee...	.....	.....	.....	.....	1,978[2]	*2,732*[1]	[2]	[2]
Indiana...	Steuben....	.....	.....	.....	.....	2,999[2]	*2,006*[1]	*1,990*[2]	*1,990*[1]
Ohio.....	Lucas.....	.....	4,565	11,447	13,186[2]	2,822[2]	*4,962*[1]	*2,585*[1]	[2]
	Erie.....	1,075	1,002	10,303	13,202[2]	[2]	[2]	[2]	[2]
	Lake.....	.....	2,725	9,853	9,316[2]	1,946[2]	[2]	[2]	.....
	Hancock...	.....	.....	.....	.....	1,990[2]	*1,998*[1]	[2]	[2]
	Huron.....	.....	.....	.....	.....	3,000	*1,985*	[2]	.....
	Summit....	.....	.....	.....	.....	2,990	*1,976*[1]	.....	.....
	Henry.....	.....	.....	.....	.....	.....	*9,558*[1]	*4,949*[1]	*4,525*[1]
Pennsylvania....	Erie.....	.....	.....	.....	9	4,461[2]	*1,969*[2]	[2]	[2]
	Crawford...	.....	.....	.....	.....	403[2]	.....	.....	.....
New York[3]	Chautauqua	.....	.....	789	4	1,997[2]	*3,826*[1]	[2]	[2]
	Erie.....	.....	.....	206	.....	16,884[2]	[2]	[2]	[2]
	Jefferson...	.....	.....	.....	.....	.....	*1,992*[1]	*2,200*[1]	*1,944*[1]

[1]Localities in which recoveries were made in season indicated.
[2]Localities in which collections were made but no parasites were recovered in the season indicated.
[3]Includes the portions of New York bordering Lakes Erie and Ontario.

The results secured from *E. crassifemur* contrast sharply with those from *M. tibialis*. The details of handling *crassifemur* were not refined until 1931, when one colony of 1,177 individuals was released in Lenawee County, Mich., at the desired date. In 1932, colonies were liberated at the later date (July) in Henry County, Ohio, and Jefferson County, N. Y., while one colony was liberated early in Monroe County, Mich. Table II shows the numbers of specimens liberated, by years, in each locality in the area.

No initial establishment of consequence has resulted from any liberations of this species. The limited number (three) of synchronized liberations which have been made do not demonstrate conclusively the impracticability of this method, but they indicate that under the conditions of these tests establish-

TABLE II.

Eulimneria crassifemur Liberated in the North Central States.

(Those shown in italics were liberated when hosts were available for parasite attack.)

State	County	1926	1927	1928	1929	1930	1931	1932
Michigan	Monroe	.....	5,359	4,913[1]	48[1]	[1]	1,342[1]	2,429[1]
	St. Clair	.....	2,195	1,706[1]	817[1]	1,451[1]	[1]	[1]
	Lenawee	.....	.....	.....	.....	606[1]	*1,177*[1]	[1]
Indiana	Steuben	.....	.....	.....	1,457[1]	1,359[1]	2,345[1]	[1]
Ohio	Lucas	1,052	2,200	3,200[1]	1,410[1]	[1]	[1]	[1]
	Erie	889	4,251	2,944[1]	[1]	[1]	[1]	[1]
	Lake	.....	2,720	2,540[1]	[1]	[1]	[1]	.....
	Summit	.....	.....	.....	705[1]	[1]	.....	.....
	Henry	.....	.....	.....	.....	4,372[1]	7,113[1]	*2,804*[1]
Pennsylvania	Erie	.....	.....	.....	196[1]	[1]	[1]	[1]
	Crawford	.....	.....	.....	354[1]	.....	.....	.....
New York[2]	Chautauqua	.....	.....	.....	640[1]	1,735[1]	[1]	[1]
	Erie	.....	.....	.....	2,478[1]	[1]	[1]	[1]
	Jefferson	.....	.....	.....	.....	.....	1,928[1]	*1,939*[1]

[1]Localities in which collections were made but no parasites were recovered in the season indicated.

[2]This includes the portions of New York bordering Lakes Erie and Ontario.

ment will not occur. Future colonization will be made at the later date, as has been done with *M. tibialis*, and should definitely evaluate the method in relation to *E. crassifemur*. However, a more careful scrutiny of the biology of this parasite may show wherein liberation technique can be so adjusted as to secure a proper contact of the parasite with its host in the field.

SUMMARY.

Overwintering cocoons of *Microgaster tibialis* Nees and *Eulimneria crassifemur* Thoms., parasites of *Pyrausta nubilalis* Hbn., imported from France to the North Central States, when exposed to natural conditions, yield adults for liberation

purposes at approximately the middle of May, i. e., two months before their host is available for parasitization in the field.

Parasite colonies of these species liberated in the field two months before their host is present in stages suitable for their attack have shown no satisfactory evidence of initial establishment.

Cold storage has been successfully utilized to prolong the hibernating period of these parasites, thereby making adults available for liberation in July when their host is present in the field in stages which they attack.

Colonies of *M. tibialis* liberated at this later period have shown initial establishment, except in a few instances. Although results to date are not encouraging, future liberations of colonies of *E. crassifemur* will be made at this later date. It may be possible to adjust the technique of liberation to meet the needs of this parasite.

LITERATURE CITED.

(1) **Jones, D. W.** 1929. Imported Parasites of the European Corn Borer in America. U. S. Dept. Agr. Tech. Bul. 98, 27 p., illus.
(2) **Thompson, W. R.** and **Parker, H. L.** 1928. The European Corn Borer and its Controlling Factors in Europe. U. S. Dept. Agr. Tech. Bul. 59, 62 p., illus.
(3) **Thompson, W. R.,** and **Parker, H. L.** 1929. The Morphology and Biology of *Eulimneria crassifemur*, an Important Parasite of the European Corn Borer. Jour. Agr. Research 40: 321–345, illus.
(4) **Vance, Arlo M.** 1932. *Microgaster tibialis* Nees as a Hymenopterous Parasite of *Pyrausta nubilalis* Hubn. in Europe. Ann. Ent. Soc. Amer. 25: 121–135, illus.

COLONY-FOUNDING AMONG ANTS, With An Account of Some Primitive Australian Species, by William Morton Wheeler. Pages i–viii and 1–179 with 29 figures. 1933. Published by The Harvard University Press, Cambridge, Mass. $2.00.

This elegant little volume is quite modernistic in that it is not divided into chapters for the short-winded and has no table of contents. However, it has an index of seven pages, a bibliography of ten pages and an excellent summary of seven pages. The first part of the text discusses the problem of colony-founding as known in the higher forms of ants. The middle portion of the book is a series of sections, one to a species, on colony-founding in the very primitive Australian ponerine ants as observed by the author. The final third is devoted to a general discussion of the problem with a synoptic summary of the known types of colony-founding which closes the text.

The form of the book puzzles the reader at first but it has many interesting passages other than its main theme of colony-founding. Australia has various fierce ants that sting and even chase the intruder for distances of many feet, a fauna entirely strange to students of the mild-mannered ants of temperate North America. Doctor Wheeler's observations indicate the changes in habit of colony-founding that in times past took place between the solitary wasps and their descendants, the more modern ants. This study fills one more gap in our knowledge of the evolution of the intricate habits of ants.—C. H. K.

NEOCONOCEPHALUS LYRISTES (REHN AND HEBARD) IN THE MIDDLE WEST

(Tettigoniidae, Orthopt.)

EDWARD S. THOMAS,
Ohio State Museum.

On October 6, 1929, the writer collected three specimens of *Neoconcephalus lyristes* (Rehn and Hebard)[1] in a marl bog known as Cedar Swamp, in Champaign County, Ohio. The species had not then been recorded west of the Atlantic coastal plain.

Subsequently specimens were taken at the same locality on August 24, 1930; August 7, 1931, and September 11, 1932. We have also found the species at Clear Lake, near Medway, Clark County, Ohio, (one male, October 4, 1931, Milton B. Trautman and Edward S. Thomas) and at Silver Lake, in Miami County, near New Carlisle, (four males, October 2, 1932, Charles F. Walker and Edward S. Thomas). On July 20, 1932, the species apparently had not yet reached maturity at Cedar Swamp, when a careful search disclosed no singing males. All specimens captured by us have been males, located by means of their song. We have done a little sweeping and have searched carefully for female specimens, without success as yet.

N. lyristes has doubtlessly been confused with the much commoner *N. nebrascensis* (Bruner) by collectors in the middle-west. Blatchley (1920, 517) states that in central and northern Indiana *nebrascensis* is the commonest of the three species of *Neoconocephalus* there occurring, and further (pp. 518–19) that Davis (Ms.) was unable to separate certain Indiana individuals from New Jersey specimens of *lyristes*, except by the labels they bore. In Ohio, *nebrascensis* is abundant in the south and very rare in the northern portions, and there seems little doubt but that some of Blatchley's northern records of *nebrascensis* should prove to be in fact *lyristes*. Unfortunately, I have been unable to obtain access to Mr. Blatchley's specimens.

[1]Determined by Morgan Hebard. My determinations of *N. nebrascensis* (Bruner), hereinafter mentioned, also were confirmed by Mr. Hebard.

Suspecting from Walker's (1904, 338) description of the habitat and song of his specimens from Sarnia, Ontario, that they were *lyristes* and not *nebrascensis*, I sent specimens of the two species to Dr. Walker for comparison. Under date of January 26, 1933, he writes that his Sarnia specimens "are undoubtedly *lyristes*, as you suspected."

An examination with T. H. Hubbell of his specimens taken in Berrien County, Michigan, shows them to be typical *nebrascensis*, as recorded by him, (1922, 60). This appears to be the northernmost unquestioned recorded occurrence for this species east of the Mississippi.

Neoconocephalus lyristes, while superficially similar to *nebrascensis* in appearance, can readily be distinguished by a number of characters. In habitat and song, the two species differ markedly.

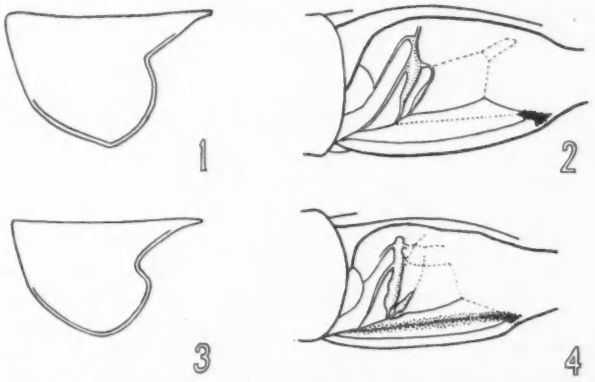
A comparison of the two species made by Mr. Hebard and the writer at Philadelphia in 1931 revealed that the most trustworthy structural character is the tegminal sinus of the pronotum, which in *nebrascensis* is decidedly "open," that is, forming an obtuse angle; in *lyristes*, it is almost rectangular. Among the series of 58 specimens of *nebrascensis* and the 15 specimens of *lyristes* in the Ohio State Museum, this character is perfectly constant and obvious, with no apparent intergradation. Another good character we found to be the long, dark line along the sinistral margin of the stridulating field in *lyristes*, which, in the other species is represented by an obscure, dark dot at the caudal end.

Rehn (1906, 366) has pointed out that *nebrascensis* is of "more robust build, with broader tegmina, wider and more arcuate tympanum, more expanded caudal section of the pronotum, and deeper lateral lobes of the same," all of which holds good with the Ohio material of the two species.

Many of the differences mentioned by Rehn, while perfectly obvious to the naked eye, are less valuable when reduced to figures since the difference is often found to result in fractions of a millimeter. Our series of Ohio *lyristes* is very constant as regards width of tympanum, eight specimens giving an average of 4.30 mm., with extremes of 4.55 and 4.13 mm. As compared with these, a series of 10 *nebrascensis* gives an average width of 4.82 mm., with extremes of 4.41 and 5.11 mm. Only one specimen of *nebrascensis*, an obvious "runt," comes within the measurements of the other species, and this individual in

relative proportions shows ratios well within those for *nebrascensis*.

The left tegmina of the eight *lyristes* average 8.38 mm. in breadth; those of ten *nebrascensis* 9.17 mm., while the average length of the former (37.6 mm.) actually exceeds that of the larger *nebrascensis* with 36.8 mm. The relative proportions of the tegmina of the two forms may best be expressed by dividing the width into the length, the resulting ratio for *lyristes* averaging 4.49, with extremes of 4.23 and 4.65; that for *nebrascensis* 4.01, with extremes of 3.57 and 4.21. The ratios in the two series approach each other, but do not overlap.



Figs. 1 and 2. *Neoconocephalus nebrascensis* (Bruner). 1, Lateral view of pronotum, showing deeper lateral lobe and shallower, obtuse tegminal sinus. 2, Tympanum, showing more arcuate form and fuscous shading restricted to small spot.

Figs. 3 and 4. *Neoconocephalus lyristes* (R. and H.). 3, Lateral view of pronotum. 4, Tympanum.

The specimens mentioned above are mounted with wings unspread. Our few spread specimens give similar ratios. Measurements were made with a micrometer disc in a binocular microscope, except in the case of the tegminal lengths which were obtained with dividers.

I find the stridulating field of the two forms to be quite distinctive in many details, particularly in the form of the heavy stridulating vein, which in *lyristes* is heaviest toward the sinistral end, while in *nebrascensis* it is widest near the middle and tapers decidedly to the left. The accessory vein at the

sinistral margin, immediately caudad of the stridulating vein is short and very heavy in *lyristes;* longer and much weaker in *nebrascensis.*

In addition, there seem to be minor differences in the coloration of the brown individuals, in the nature of the maculation of the tegmina and in the form of the fastigium of the vertex, though the latter characters shows considerable of variation, especially in *nebrascensis.*

The song of *lyristes* is a continuous, uninterrupted, loud, thin buzz, which might be paraphrased thus: "Bz-z-z-z-z-z-z-z." It is continued for indefinite periods. In our experience, the insect begins to sing in full sunlight late in the afternoon. Walker reports his specimens as singing in the morning hours.

The song of *nebrascensis* does not closely resemble that of any other member of the genus, so far as I am aware. It consists of a series of buzzing notes of a lower pitch than that of *lyristes.* Each note lasts for a trifle more than one second and is followed by a pause of a half-second or less, the series of notes thus forming a rhythmical song which is continued for an indefinite period, thus: "Bz-z-z-z-z-t, bz-z-z-z-z-t, bz-z-z-z-zt, . . ." I have never heard *nebrascensis* sing before sunset.

All three of the Ohio localities in which we have taken *lyristes* are apparently glacial relict bogs, showing a decided prairie influence in their vegetation. The species has invariably been associated with (although not always in) Shrubby Cinquefoil (*Dasyphora fruticosa*) and it has also been taken frequently on Big Bluestem grass (*Andropogon furcatus*). Cedar Swamp is the only arbor-vitae bog remaining in Ohio. All of the bogs in question contain many plants which are either of boreal or of prairie orgin, such as *Toxicodendron vernix, Triadenum, Ibidium cernuum, Lobelia kalmii, Parnassia caroliniana, Solidago ohioensis, S. riddellii, Sorghastrum nutans, Agalinis purpurea, Sanguisorba canadensis,* and *Anticlea elegans.*

As contrasted with the habitat of *lyristes, nebrascensis* occurs normally in boggy spots in or near woodland, and in sloughs and river-bottom marshes bordered by willows or other trees. It seldom occurs far away from trees of some sort and in fully fifty percent of the cases, we have found the singing males perched in woody vegetation. At Cedar Swamp, the only locality where we have noticed both species, *nebrascensis* occurred in trees and shrubbery around the border of the bog, while *lyristes* invariably was found over the marl bog itself,

either in the *Dasyphora* heath or in prairie grasses. At this locality *N. ensiger* occurred commonly associated with *lyristes*, although the former species was more abundant in the weedy sedge meadows nearer to the borders of the bog.

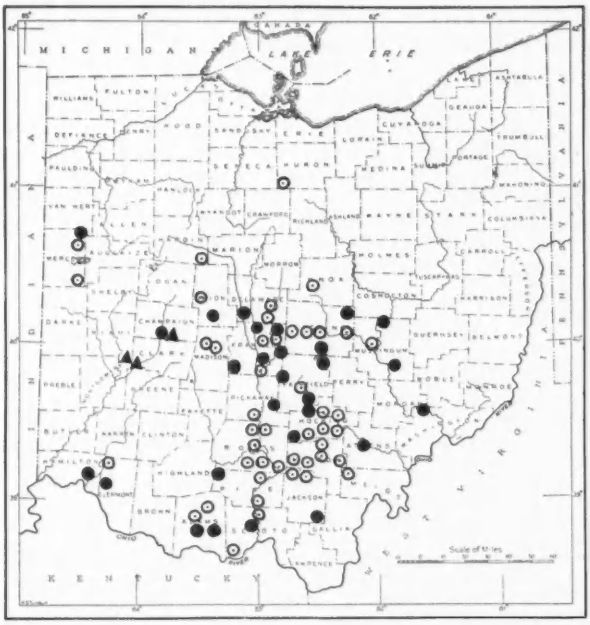


Fig. 5. Map showing known distribution of *Neoconocephalus nebrascensis* and *N. lyristes* in Ohio. *Nebrascensis*, dotted circles indicate sound records; black circles, records of specimens collected. *Lyristes*, black triangles, records of specimens collected.

It seems altogether probable that *Neoconocephalus lyristes* may have invaded the Great Lakes region from the Atlantic seaboard in early postglacial times by way of the Mohawk-Hudson outlet, over the same route believed to have been followed by a number of Atlantic coast plants.[2] On the other hand, *nebrascensis* would seem probably to be of western origin.

[2]It is also of interest in this connection to note that Cedar Swamp is the only known Ohio station for the grasshopper, *Paroxya atlantica* Scudder, a species with a range similar to that of *N. lyristes*. *Argia bipunctulata* (Hagen), has also been recorded by Donald J. Borror (Ohio Jour. Sci., 30: 414, 1930) from this bog, which is the first record west of the Alleghenies for this dragonfly.

In view of the very different songs of the two forms, the distinct structural and color characters, the occurrence of both within the same range in portions of the middle west and the absence of known intergrades, it seems certain that *lyristes* cannot be a subspecies of *nebrascensis*, as placed by Blatchley (1920, 518), but that it represents a distinct species, as originally described by Rehn and Hebard (1905, 45).

LITERATURE CITED.

Blatchley, W. S. 1920. Orthoptera of Northeastern America. Nature Publishing Co., Indianapolis.

Hubbell, Theodore H. 1922. The Dermaptera and Orthoptera of Berrien County, Michigan. Occ. Papers of the Mus. of Zoology, No. 116. University of Michigan.

Rehn, James A. G. 1906. Conocephalus lyristes. Ent. News, XVII: 366–7.

Rehn, J. A. G. and **Hebard, Morgan.** 1905. A Contribution to the Knowledge of the Orthoptera of Southern and Central Florida. Proc. Acad. Nat. Sci. Phil., 29–55.

Walker, E. M. 1904. Notes on the Locustidae of Ontario. Can. Ent. XXXVI: 337–341.

INSECTS. A Book for Teachers, Students, and All Others Interested in the Vast World of the Six-footed. Western Nature Study Series, Gayle Pickwell, Editor. Pages i–xv and 1–304; 139 figures, incl. colored frontispiece. 1933. Published for The Natural Science Department, San Jose State Teachers College (Calif.), by Suttonhouse, San Francisco. $3.00.

It is refreshing to find a book in which all of the illustrations are original, but to our task! As indicated in the table of contents this volume is a product of joint authorship. Of the twenty chapters, eight are by Gayle Pickwell, eleven by Carl D. Duncan and one by Karl S. Hazeltine, who, with Emily Smith are Editors of the Western Nature Study Series. Some of the photographs by Pickwell are very good. The line drawings are good, but should have had much more reduction by the engraver.

This book is well bound, printed on excellent paper and appears to be a very high grade of natural history. Structure, function and general behavior are woven together all the way through it. Only one chapter (XII) is given to systematic entomology, one to the value of insects and one to harmful insects. Chapter XX is an excellent summary and discussion of the general literature of insect life available to teachers in nature study.

This volume gave the reviewer a real thrill as he has mourned many times over the serious lack of amateur groups in this country that are interested in insects. The United States is one of the richest entomological fields in the world. Perhaps its very richness has overwhelmed the amateur in that he cannot get his material named. We lack the numerous excellent handbooks available in Europe on European insects and in many groups will lack them for many years to come. Probably some blame for this lack of general interest can be laid at the door of our high schools whose superficial teaching arouses little interest in the minds of bright students. The numerous amateur entomologists of Europe appear to come from the private schools of England and the excellent secondary schools on the continent. May we not hope in vain for more books of this type from our Colleges of Education and State Normal Schools!—C. H. K.

ON THE ANATOMY OF GRYLLOBLATTA COMPODEIFORMIS WALKER.

2. Comparisons of Head with those of other Orthopteroid Insects

E. M. WALKER,
Department of Biology, University of Toronto.

The following paper is a sequel to the writer's study of the head capsule and its appendages of Grylloblatta (Walker, '31b) and is a contribution to the materials necessary to a final decision as to the systematic position of this primitive insect and the interrelationships of the various orthopteroid groups. It is our intention in future papers to discuss the other regions of the body in a similar manner and to withhold our final judgment on Grylloblatta's relationships until the study is completed.

The need of a detailed study of this insect is indicated by the numerous opinions that have been expressed regarding its systematic position.

In the original description of Grylloblatta (Walker, '14), based on the female only, the genus was placed in a new family of Orthoptera (sens. lat.), the Grylloblattidae, which was believed to combine characters of the Saltatoria and Cursoria, as indicated by the generic name chosen.[1] The genus was believed at this time to be, on the whole, most nearly related to the Blattidae, although more in the direct line of evolution of the Saltatoria. After the discovery of the male, however, (Walker, '19a), Grylloblatta was thought to be perhaps of still more ancient lineage, representing a descendant of orthopteroid stock ancestral to any of the modern groups. This view was based upon the presence of archaic features absent in both cursorial and saltatorial branches of Orthoptera, such as the primitive division of the 9th abdominal zygosternum of the male and the lack of specialization of any of the abdominal sterna of the female to form a subgenital plate.

[1]It should be mentioned that the names Gryllus and Blatta, thus combined, have only a general significance, Gryllus being used in the Linnaean sense to typify the Saltatorial Orthoptera as a whole, and Blatta to represent the Cursoria in a similar manner.

This view was, however, again slightly modified as a result of a general study of the terminal abdominal structures of orthopteroid insects (Walker, '19b and '22). Influenced by the strikingly blattoid genitalia of the male Grylloblatta, the line of descent of the latter was shifted from the common orthopteran stem to the base of the blattoid or cursorial branch. Ford ('23) came to a similar conclusion from a study of the abdominal muscles. These she regarded as, in the main, more like those of the Blattids and Mantids, although the muscles of the female gonapophyses were nearer those of the saltatorial families Gryllidae and Tettigoniidae.

From 1915 to 1927 a number of papers by Crampton appeared, dealing with the affinities of Grylloblatta. The views expressed are so numerous, however, that it would be of little value to repeat them here. Suffice it to say that Crampton has found Grylloblatta's nearest relatives among such diverse groups as the Dermaptera and Isoptera, the Embiids, Phasmids, Mantids, Zoraptera and the saltatorial families Tettigoniidae and Gryllidae. In the first paper of the series ('15) he erected for the genus a new order Notoptera, changing this name later to Grylloblattida and Grylloblattoida. Finally in his latest paper ('27), dealing with the subject from all available data, Crampton considers Grylloblatta to represent a family of Orthoptera (sens. strict.), most nearly related to the Tettigoniidae and Gryllidae.

Imms ('25), in his textbook, placed the family Grylloblattidae in the Cursoria, in which he included the Phasmidae, as well as the Blattidae and Mantidae. This view is upheld in an article on the affinities of the Grylloblattidae (Imms, '27), in which a number of arguments are advanced in its support and opposed to Crampton's latest view ('26 and '27).

It thus seems to be generally admitted that the Grylloblattidae are an extremely generalized family, but it is evident that a more complete knowledge of their anatomy is necessary before the exact relationships of this family to other groups can be established. This knowledge should also throw light upon the interrelationships of all the lower Pterygota.

MATERIAL.

The species selected for comparison with Grylloblatta were taken from the more generalized orders of Exopterygota. It

seemed unnecessary to include representatives of groups whose affinities with Grylloblatta are obviously more distant, such as the Ephemeroptera, Odonata and Mallophaga. The Psocoptera might have been included, especially the primitive suborder Zoraptera, but material was not available and, in any case, their relationships with Grylloblatta appear to be more remote than those of the groups considered here.

The following species were selected as the principal types representative of the orders or major groups considered. Their classification, as given below, is provisional.

Order.	Suborder.	Representative Species.
Plecoptera		*Taeniopteryx nivalis* Fitch.
Embioptera		*Oligotoma hospes* Myers.
Dermaptera		*Forficula auricularia* L.
Orthoptera	Isoptera[2]	*Termopsis angusticollis* Hag.
	Dictyoptera	*Parcoblatta pensylvanica* DeG.
		Stagmomantis carolina Johann.
	Phasmatodea	*Diapheromera femorata* Say.
	Saltatoria	*Gryllus assimilis* Fabr.

THE HEAD CAPSULE.

A glance over the species listed above will show that, with the exception of the Dictyoptera and Saltatoria, all have prognathous heads and this type of head is general in the groups to which they belong. The forerunners of the Orthoptera, the fossil Protorthoptera (including Protoblattoidea) were likewise prognathous and it therefore seems logical to conclude that prognathism is primitive as far as the orthopteroid insects are concerned, although not in the Arthropoda as a whole.

With the forward position of the jaws is associated the following features:

(a) The head capsule is more or less depressed.

(b) The antennae arise far forward near the articulation of the mandibles and their bases are wide apart.

(c) The compound eyes are laterally placed and are likewise far forward. In consequence of this position there is little development of a gena.

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[2]I have included the Isoptera in the order Orthoptera because their close relationships with the Blattidae are generally recognized. They are quite as closely related to this family as, e. g., the ants (Formicoidea) are to the sawflies (Tenthredinoidea) in the order Hymenoptera. If the Isoptera are to be retained as a separate order, then it is logical to give the same rank to the Dictyoptera, Phasmatodea, Grylloblattodea and Saltatoria (Orthoptera *s. s.*). This appears, on the whole, to be undesirable, since the characters which separate these groups are scarcely of ordinal rank according to the prevalent concept of this rank among students of Arthropoda. We therefore prefer to regard these groups as suborders.

(d) In primitive forms the plane of the occipital foramen[3] is oblique, sloping from above downwards and forwards, and correlated with an elongation of the cervical membrane.

In more specialized prognathous forms there may be also a backward elongation of the postgenae, which brings about a more vertical position of the occipital foramen.[3] (e. g., specialized Plecoptera, cf. prognathous Coleoptera). In other forms there is an elongation of the submentum (Isoptera, especially the soldier caste) and, in still others, an additional sclerite or "gula"[4] is developed behind the submentum (Dermaptera and Embioptera) or, finally, there may be merely a thickening of the elongated cervical membrane itself, which nevertheless remains flexible (Phasmatodea).

When the jaws become shifted from an anterior to a ventral position, as in the Saltatoria and Mantidae, that surface of the head which was formerly dorsal now becomes convexly curved or bent, the posterior part usually remaining dorsal while the anterior part becomes the face and is more or less vertical or may even slope backwards.

In the Saltatoria (Tettigoniidae, Locustidae) this change of form appears to be due mainly to an expansion of the frontogenal region and, as a result, the eyes and antennal bases become more or less distant from the epistomal and subgenal sutures, the eyes, at least, retaining their dorsal and anterolateral position. The head is compressed, like the other regions of the body, just as the prognathous head is usually depressed and associated with a similarly flattened body. With the compression of the head the eyes and antennae are not only elevated from their primitive position but are also brought nearer together.

The mantid head is differently modified. Its peculiarities of form appear to be correlated with the huge size and lateral prominence of the eyes, which have, as it were, thrust the head capsule outwards, thus increasing its width and reducing its length and at the same time causing a marked anteroposterior tergal flexure. In contrast to the grasshoppers the frons and genae are but little changed from their primitive condition, but the interocular region or vertex is considerably expanded.

The Blattidae are decidedly peculiar, for, notwithstanding their flattened form, the head, although sharing in the depression, is not prognathous but bent under the prothorax in such a way that the face is almost ventral and the jaws directed backwards. Here, as in the grasshoppers, though to a lesser extent, the eyes and antennal bases have migrated from their primitive position, but, except in the strong curvature of the dorsal into the facial surface of the head capsule, the latter is remarkably little modified.

It is evident from a consideration of insects in general that the change from the prognathous to the hypognathous type of head or vice versa has taken place many times and is one of those adaptive changes which

[3]The occipital foramen is here considered as being bounded in front and below by the posterior arms of the tentorium.

[4]This sclerite is not homologous with the true gula of the Coleoptera and other Endopterygota.

are of very little significance from the phylogenetic standpoint. At the same time we believe that, in the primitive groups here considered, the form of the head is of some importance, since, in each of these groups, a particular form of head capsule, with only minor variations, is characteristic.

In the general form of the head capsule, including the tentorium, Grylloblatta is distinctly dermapteroid, or at least forficuloid. In Forficula (Pl. I, Figs. 1A, B, C), e. g., the head is similarly flattened and prognathous, with the antennal sockets near the bases of the mandibles and separated by a wide median space; the occipital foramen posteroventral in position and the postgenae elongated in much the same manner. The epistomal, subgenal and occipital sutures are also much like those of Grylloblatta. The epicranial suture is much more distinct in the adult and is more posteriorly situated. It is regarded by Snodgrass ('28) and Crampton ('32) as distinct from the true epicranial suture and is termed by the latter author the parafrontal suture. We see no valid reason for making this distinction and believe it to be based upon a misconception as to the primitive nature of this suture. The clypeus and labrum likewise share in this similarity, although the tormae are much stronger in Forficula. The sense of sight is obviously better developed in the earwig, as indicated by the larger compound eyes and the presence of distinct ocelli, but the compound eyes of the two forms are not unlike in both form and position.

The most distinctive feature of the head capsule of Grylloblatta is the presence of parietal or temporal (Crampton, '29) sutures and ridges. These are absent[5] from the more heavily sclerotized head capsule of Forficula. The much smaller size of the occipital foramen in the latter is also noteworthy. The tentorium, except for minor differences in proportion, has essentially the same form as in Grylloblatta, the most obvious differences being the better developed dorsal arms and the relatively smaller posterior arms with less elongated posterior tentorial pits.

The presence of a gula or guliform sclerite in the Dermaptera is an important feature that is wholly lacking in Grylloblatta. The gula of Forficula is not fused with the head capsule, nor with the submentum, but is closely connected with the latter. It does not, however, appear to represent a secondary division of the submentum, since it lies entirely behind the posterior tentorial pits. It seems also improbable that it represents a true sternum of the labial segment, as suggested by Henriksen ('29), since it is absent in the more primitive insects in general; but is rather to be regarded as a secondary sclerotization of the usually membranous region immediately behind the submentum, i. e., the anterior part of the cervical membrane.

The head capsule of Oligotoma (Pl. I, Figs. 2A, B, C) is another example of the flattened prognathous type, with eyes and antennal sockets anterolaterally placed, the former very like those of Grylloblatta in form, size and position, while the antennal sockets differ only in

[5]They are indicated in figures by Crampton ('32, Pl. 5, Fig. 17.) but I find no indication of their presence.

being more laterally placed. The shorter clypeus and labrum and narrower postocular region give the head a rather different general appearance, less like the majority of orthopteroid insects than that of Grylloblatta.

Oligotoma further resembles Grylloblatta in the absence of ocelli, the somewhat faint epicranial suture, whose arms nearly reach the antennal sockets and the form and position of the subgenal suture. The ventral aspect of the head capsule is, however, strikingly different from either Grylloblatta or Forficula. What appear to be the occipital sutures do not extend back to the occipital region but are developed only in the region of the mouth-parts where they are continuous with the front edge of the gula, (v. inf.) and form the boundary of a depression in which the maxillae and labium lie. No parietal sutures are present.

The gula of Oligotoma seems to be of the same general nature as that of Forficula, but is completely fused with the postgenal region of the head capsule, separating the posterior arms of the tentorium from the occipital foramen and thus forming a second foramen bounded by the posterior tentorial arms in front and the gula behind.

The tentorium itself is shorter than in Grylloblatta and Forficula, the body more nearly rectangular, the dorsal arms feeble and basally fused with the anterior arms, and the posterior arms are not so nearly transverse. The posterior tentorial pits are not prolonged backwards, the ventral elongation of the head capsule being virtually confined to the region behind these pits.

The Plecoptera are another group of insects with prognathous heads, forwardly placed and widely separated antennae, and eyes not far from the mandibular articulations. The posterior part of the head is, however, so short that the eyes, which are rather prominent, usually appear to be as near the hind margin of the head as the front, or even nearer. This lack of development of the back part of the head is correlated with the small size of the mandibles and the correspondingly limited area of origin of the mandibular adductor muscles.

The head capsule of Taeniopteryx (Pl. I, Figs. 3 A, B, C) is typical of the Nemouridae and that of the Capniidae is essentially similar. These are primitive Plecoptera, as pointed out by Hoke ('24), and in the structure of their head capsule they resemble Grylloblatta much more closely than do the larger species of the families Perlidae and Pteronarcidae. The labrum is prominent and has a membranous base with thickened margins and well-developed tormae. The clypeus is small as compared with that of most Plecoptera, and is somewhat constricted but is separated from the frontal area by the well-marked epistomal suture. This is continued laterally along the ventral margin of the antennal socket, beyond which it passes into the subgenal suture. In these features the resemblance to Grylloblatta is very close. On the other hand the occipital suture is wholly undeveloped and the epicranial suture, in the adult, is obliterated. The tentorium is of the same general type as those of the forms already considered. The anterior and posterior arms are of more nearly equal size, the former being relatively short, the latter long, as compared with Grylloblatta

or Forficula; and the body of the tentorium is of nearly equal width at the bases of the arms, although somewhat constricted in the middle. The dorsal arms arise in common with the anterior arms and join the roof of the head capsule just behind the antennal sockets. The occipital foramen faces ventroposteriorly and is rather wide. It includes the space between the posterior arms of the tentorium, there being no development of a gula.

In the adults of the families Perlidae and Pteronarcidae the reduction of the mandibles is associated with absence of the epistomal suture and a marked shortening of the posterior region of the head. The clypeal region, though ill-defined, is more or less expanded and overlaps the dorsal articulation of the mandibles. The occipital foramen in these specialized forms, as pointed out by Hoke ('24), tends to acquire a posterior instead of a posteroventral position, which is the more primitive position in prognathous insects. In the more specialized perlids the tentorium, like other parts of the head capsule, diverges considerably from the primitive type seen in Taeniopteryx. In correlation with the shortening of the postocular region of the head and the prominence of the clypeal region the body of the tentorium becomes more or less transverse and the anterior arms very long, the dorsal arms arising from the latter far from their bases. These peculiarities give the impression at first that the body of the tentorium in these perlids is formed by the fusion of the posterior arms only, but Hoke (l. c.) has shown by a comparison of many genera that this is not the case and that the transverse type of tentorium is only a more specialized form of the same type as occurs in Taeniopteryx.

Thus, although the head capsule of Grylloblatta is considerably different from that of the specialized Plecoptera, it differs from that of Taeniopteryx in little except the proportions of parts and the absence of certain sutures.

The phasmid head capsule, as represented by Diapheromera (Pl. II, Figs. 4 A, B, C) may be taken first of the orthopterous types, being one of the few in which prognathism has been retained. This characteristic is in fact strongly marked and the correlated features, especially the lengthening of the postocular region of the head appear exaggerated, owing to the general elongation of all the parts. The elongation of the head capsule is chiefly in the tergal parts, the occipital foramen being drawn out into a long oblique oval, closed in ventrally by a forward extension of the cervical membrane. The posterior tentorial pits thus appear to be carried forward, and with them the labium and maxillae. The tentorium is somewhat like that of the specialized Plecoptera in the short body, long anterior arms and points of origin of the dorsal arms. The long anterior arms and almost vertical position of the body of the tentorium are associated with the unusual depth of the fore part of the head, due to the huge mandibular bases. The anterior tentorial pits are immediately beneath and somewhat laterad of the bases of the antennae and a little farther from the bases of the mandibles than in Grylloblatta. The epistomal and subgenal ridges and sutures are well developed, but the epicranial, parietal and occipital

sutures are all absent. The clypeus and labrum are short and flexible, the latter deeply emarginate. The distance between the two mandibular articulations is unusually long, the ventral one being remarkably far back. There is no gula, in spite of the elongated cervical membrane, which is flexible, although somewhat thick and leathery.

On the whole the head capsule of Diapheromera differs from that of Grylloblatta more widely than those of the other types thus far noticed in the form and proportions of parts, the posterior tergal region being elongated without any proportional lengthening of the ventral region, so that the labium and maxillae appear relatively small and shifted forward, and the occipital foramen very long and oblique. In spite of these marked differences of form the head capsule of Diapheromera is fundamentally like that of Grylloblatta. It should also be mentioned that more primitive phasmids, such as Timema, are more like Grylloblatta in the form of the head than is Diapheromera.

Considering next the Saltatoria, we may take *Gryllus assimilis*, the common field cricket (Pl. II, Figs. 5 A, B, C), as our type, since the head capsule is less modified in the Gryllidae than in the other families. The chief peculiarities of the Saltatoria depend on the alteration in the position of the jaws from a subhorizontal and anterior to a more or less vertical and ventral one. With this difference in the position of the jaws are associated differences in the relative positions of other parts of the head capsule. The frontal and clypeal regions, together with the labrum, are changed from a dorsal or anterodorsal position to an anterior or ventroanterior position, and are more or less sharply demarcated from the dorsum at the vertex. The originally ventral surface of the head becomes posterior and carries with it the hypopharynx, maxillae and labium. It now comes to lie in the same plane as the occipital region, and the position of the occipital foramen is changed from a posteroventral to posterior one. The long axis of the head is now perpendicular or nearly so and the eyes and antennal bases are farther removed from the bases of the clypeus and mandibles than in the primitive head capsule, and are also nearer the middle line. These modifications are but slightly marked in Gryllus and other Grylloidea, which are somewhat depressed forms with a trace of prognathism still present.[6] In most Saltatoria the body is more or less compressed and the head much deeper, the eyes and antennae being far removed from the clypeus and mandibles and more or less closely approximated above. The space thus developed between the lower margin of the eye and the subgenal suture is the gena. A very distinct frontogenal suture, scarcely noticeable in more primitive forms, is present in these specialized forms and represents the distal portions of the frontal sutures, the proximal parts of which, together with the coronal suture, are usually obliterated in adult grasshoppers, though distinct in Gryllus and other crickets.

In other respects the head capsule of Gryllus resembles that of Grylloblatta rather closely. The labrum is very similar, the clypeus

[6]This is especially true of the Gryllotalpidae, the fossorial habits of which are probably responsible for a return to an almost prognathous condition.

shows a more marked division into ante- and postclypeus, more so in fact than in most Saltatoria; and the epistomal, subgenal and occipital sutures are all much like those of Grylloblatta, although the occipital suture is continuous around the occipital region. This difference is unimportant, however, since in other forms, such as Ceuthophilus, this suture is incomplete, as in Grylloblatta and Forficula. The tentorium is remarkably like those of the latter genera, the body being widest in front, narrowed and constricted behind, the anterior arms large and broadly expanded, the dorsal arms arising separately from the body, and the posterior arms forming a practically transverse bar. The posterior tentorial pits are not elongated and the occipital foramen is shorter than that of Grylloblatta, as would be expected from its position. No trace of a gula is present.

In some primitive genera, such as Ceuthophilus (Stenopelmatidae) there is an incomplete fusion of the anterior arms of the tentorium, so that the anterior bridge (frontal plate) is excavated in front, and the base of each anterior arm bears a mesial projection, but a separate foramen for the crura cerebri never occurs, so far as is known.

The remaining suborders of Orthoptera, the Dictyoptera and Isoptera, may be separated from those already considered by the form of the tentorium, which is perforated by an aperture for the crura cerebri, this aperture being due to an incomplete fusion of the anterior and posterior bridges. Of these two suborders the Isoptera are much the nearer to Grylloblatta, as far as the head capsule is concerned, and that of Termopsis (Pl. III, Figs. 8 A, B, C) shows this very clearly. Here again we have the prognathous head with eyes and antennae far forward and laterally placed, genae small, and postgenae and submentum elongated. The elongation of the postgenae is, however, chiefly in the region behind the bases of the maxillae, including the posterior tentorial pits, which are drawn out behind into slits. This is particularly noticeable in the soldier caste, in which the entire postocular region of the head is greatly elongated. The posterior arms of the tentorium are broadly united by the posterior bridge, which in the soldier caste is prolonged backward to form the roof of a neural canal, the floor of which is formed by the submentum. In other respects the tentorium recalls the dictyopterous type, but is more like that of Grylloblatta than are those of either blattids or mantids. The anterior arms are very long and their basal portions united by a thin anterior bridge. From the upper and outer surfaces of the free portion of the arms, close to the base, arise the extremely slender dorsal arms. There is a round median aperture similar to that of Parcoblatta.

The clypeus of Termopsis is much shorter than in Grylloblatta, scarcely projecting beyond the bases of the mandibles. It is distinctly divided into a membranous anteclypeus and a firm postclypeus, bounded behind by a definite epistomal suture. The subgenal suture is well developed. The frontal sutures are clearly marked and terminate in front between the antennal socket and the front margin of the eye. The coronal suture is obsolete in the adult but is well defined in the earlier stages of some Isoptera. Parietal sutures do not occur. The

occipital sutures converge behind to join the transverse posterodorsal margin of the occipital foramen, thus differing from those of Grylloblatta and Forficula.

In the Dictyoptera the jaws have changed from the forward position, being directed either ventrocaudad (Blattidae) or ventrad (Mantidae). In Parcoblatta (Pl. III, Figs. 9 A, B, C) and other Blattidae the head, though flattened, is not prognathous, the face being almost ventral in position and the jaws directed backwards. This change in the position of the head is due mainly to the manner of its connection with the prothorax, but also to the pronounced curvature of the cephalic dorsum, which is situated farther back than in the Saltatoria, i. e., in the interocular region behind the ocelli. As in the latter group the antennae arise far from the mandibular bases and the eyes, which are very much larger than those of the other forms hitherto considered, occupy a large part of the dorsal and lateral regions of the head, and even their lower margins are farther from the base of the mandibles than in prognathous forms. The eyes, in fact, extend so far dorsad that their hind margins are joined by the dorsal ends of the occipital sutures. The anterior tentorial pits are just above the bases of the mandibles and the line of origin of the anterior arms of the tentorium extends upwards and outwards from this pit, meeting the rather feeble subgenal suture at an acute angle, from which a short subocular spur is given off, representing the lower end of the frontogenal suture. The epistomal suture is mesially obsolete, the frons and clypeus being continuous. The clypeus and labrum are, however, as long as in Grylloblatta, and very like those of the latter in form, although no distinct anteclypeal region is present.

The tentorium is remarkable for its large anterior bridge with its nearly straight front margin, large median aperture and small posterior bridge. The anterior and posterior arms are not unlike those of Grylloblatta, except for the shortness of the former, but the dorsal arms are apparently absent. They are present, though very attenuated in Periplaneta (Mangan, '01). The occipital foramen, as in the Saltatoria, lies in the same plane as the postgenae and mouth-parts, but the actual position of this plane in life is, of course, posterodorsal instead of posterior. The foramen is small and there is no development of a gula.

The head of a mantid, such as *Stagmomantis carolina* Johann., (Pl. III, Figs. 10 A, B) may be likened to that of a cockroach highly modified for predacious life. It is similarly flattened, with the dorsum short and convexly curved in like manner. The great breadth of the head as compared with its length and depth is due to the huge size of the compound eyes and the interocular area on which are situated three very large ocelli. The face is vertical but quite short, although there is some expansion of the frons, as indicated by the position of the antennae which are some distance above the epistomal suture. The gena, however, is little developed on account of the large area occupied by the eyes. The occipital foramen is small, to permit of free movements of the head, but the margins are well sclerotized and bear a pair of large tubercles for the insertion of muscles from cervical sclerites.

The occipital ridges are also strong in their dorsal parts, where they are continued forwards, parallel to one another, almost to the ocellar triangle. These are anterior extensions of the occipital ridges, forming a pair of arches, which strengthen the head capsule and are thus analogous to the parietal ridges of Grylloblatta. The epistomal ridge is also greatly thickened to brace the powerful mandibles. The subgenal suture is feeble, as in Parcoblatta, and the frontogenal suture is similar but better marked, running well up in the space between the antenna and eye. The clypeus and labrum are similar to those of Parcoblatta.

The tentorium of Stagmomantis is highly modified. The anterior arms are long and remarkably broad, without the usual twist. They form a strong base for the powerful mandibles. The dorsal arms are well developed and arise from the posterior margins of the anterior arms. There is a constriction just behind the broad anterior bridge, posterior to which is the median aperture, bounded by two backwardly diverging posterior arms, which are connected only at their extreme bases by a transverse bar which represents the posterior bridge.

THE ANTENNAE.

The antennae are subject to such wide variation within each order in length, number and form of segments, distribution of setae, etc., that little is gained by the comparison of a few types. The position of the antennal socket is of some importance but has already been considered. The antennae of Grylloblatta are most like those of the Embioptera in the form and number of the segments, as already noted by Crampton ('17a). In Oligotoma, according to Enderlein ('12) the number of segments ranges from 19 to 24 and, in the Embioptera in general, appears to be usually but not always slightly smaller than in Grylloblatta. The segments are somewhat shorter and more rounded, approaching those of the Isoptera. The antennae of Forficula also approach those of Grylloblatta in the general form of the segments, and intersegmental constrictions, but the scape is much longer and the remaining segments increase more rapidly in length and are in general longer, while their number is only about half that of Grylloblatta. Termopsis has about the same number of antennal segments as Grylloblatta, but they are shorter and more bead-like, with very marked intersegmental constrictions. The antennae are, in fact, distinctly moniliform. Some of the Saltatoria have antennae similar to those of Grylloblatta in length and number of segments, e. g., the Locustidae; a few have a smaller number, such as the Tridactylidae and Cylindrochaetidae, but the long multiarticulate type is commonest in the more primitive forms. The antennae of Ceuthophilus and Gryllus also differ from those of Grylloblatta, as do those of the Saltatoria in general, in the absence, or slight indication of, the intersegmental constrictions. The same is true of Diapheromera, Parcoblatta and Stagmomantis. In Gryllus the scape is very stout as compared with all the other segments; in Diapheromera both scape and pedicel are very stout, while the flagellum is very slender and the segments usually elongate and

irregular in length. In Parcoblatta the scape is constricted near the base so as to be almost divided, the second and third segments are moderately large, and the remaining segments of the flagellum are very numerous and, for the most part, are very short and annular, but distally, as they decrease in diameter, they increase in length, so that, at the apices, they are much longer than thick.

The antennae of Stagmomantis are of the same general character but much shorter. They diminish in thickness rapidly from a stout scape to a slender flagellum, the first segment of which is long, the second very short, and the remainder gradually increasing in length as in Parcoblatta.

The antennae of the Plecoptera are also of the slender, tapering multiarticulate type, but, in some of the small forms like Capnella, the segments are fewer and relatively larger. In Taeniopteryx the segments are not unlike those of Grylloblatta, though more numerous. They are similarly clothed with short hairs.

THE HYPOPHARYNX.

The hypopharynx in orthopteroid insects is a tongue-like lobe of very variable form. The apical and oral surfaces are usually partly membranous and densely clothed with minute sensory hairs, the surface elsewhere being covered with a cuticle which is in part quite flexible but is more or less thickened around the base and along the sides. These firmer areas consist mainly of the lateral and suspensorial bars. The lateral bars usually meet ventrally at the base, forming a v-shaped sclerite, whose apex is connected with the labial apodeme. The suspensorial bars are more or less closely connected with the lateral bars and meet one another mesially, forming an arch over the base of the hypopharynx. The dorsal arch and the ventral v-shaped sclerite, or its equivalent, form a girdle for the support of the base of the organ. The median parts of the suspensorial bars and sometimes other, more distal parts of the oral surface may be clothed with thick-set hairs, which appear to serve as a cleaning brush for the antennae and tarsi (Verhoeff, '04). Two branches are given off basally from each suspensorial bar, a larger, mandibular branch, on the basal end of which is inserted the tendon of the superior protractor muscle[7] of the hypopharynx, when this is present, and an oral branch, which forms the lateral framework of the mouth and on which are inserted the retractor muscles of the mouth angles. The median parts of the suspensorial apparatus are frequently more or less asymmetrical owing to their close apposition with the asymmetrical inner margins of the mandibles, and this asymmetry may extend to the entire oral surface of the organ.

A salivary cup is usually but not always present. It is particularly large in the mantids and blattids.

[7]This is the small muscle which arises within the mandible and was described by the writer ('31), following Snodgrass ('28), as a vestigial ventral adductor of the mandible. It certainly functions as a muscle of the hypopharynx rather than the mandible.

The hypopharynx of Forficula (Pl. II, Figs. 6 A, B, C) differs from those of all our other types in bearing a pair of distal lateral lobes which probably represent either vestigial superlinguae or paragnaths.[8] The ventral surface is covered by a thin, slightly convex sclerite, which bears a firmer triangular basal projection (the *radix* of Verhoeff, '04), connected with the labial apodeme. Verhoeff regarded the lateral plates as distinct from the ventral one, but in the specimens I have examined they appear to be completely fused with the ventral plate. Each lateral plate bears a row of long tactile hairs and, on its inner surface, is a straight ridge which extends distally into the superlinguae of the same side and forms the principal lateral support of the hypopharynx. The apical lobe of the hypopharynx lies between the ventral plate and the oral (dorsal) integument and is a membranous, tongue-like structure, bearing minute sensillae. The oral surface behind and above the lobe is asymmetrical, the median line being shifted distally to the left. It is covered by a flexible integument, supported by an asymmetrical framework of bars, which represents the median part of the suspensorial apparatus. Near the middle is a pair of raised and thickened areas, separated by a narrow median groove and together forming a slightly asymmetrical median crest. These plates are covered with hairs and form the cleaning brush (Verhoeff, l. c.). They fit into a space between the mandibles when these are closed. Connected with the front of the brush is an asymmetrical transverse arch, formed by two sclerites, of which the right bears a strong process extending forward and projecting downward beneath the surface of the integument. The outer ends of this arch are bifurcated, one branch joining the lateral bar of its side, the other bending inward close to the brush and thence, curving outward and backward, divides into the oral and mandibular branches, which are of about equal size. All the parts, except at the extreme base, are strikingly asymmetrical.

The hypopharynx of Gryllus (Pl. IV, Figs. 11 A, B, C) most nearly approaches that of Forficula in the complex structure and asymmetry of its suspensorial bars, though very different in certain other respects. It is a thicker structure than in Forficula, having a longer base and a broadly triangular profile, the ventral surface meeting the oral at a wide angle. Viewed from below it appears broadest near the apex and narrowest at the base, while from above it is more nearly parallel-sided. Its apical region, including parts of the ventral and oral surfaces, is membranous and much folded in the retracted state, but the ventral surface is partly covered by a pair of thinly sclerotized flaps, which are ventral expansions of the lateral bars. These bars converge towards the base at an acute angle, meeting at the narrow salivary cup. Their broader portions are connected with the suspensorial apparatus through the lateral walls, which are likewise thinly sclerotized and divided by an oblique suture into two areas. The integument of the oral surface is for the most part flexible and is somewhat asymmetrically divided into a number of areas. Of these the best defined are two pairs of

[8] They are regarded by Hansen ('30) as probably maxillulae (superlinguae), not paragnaths.

pigmented, hairy elevations on the basal half of this surface, the larger, distal pair separated by a smooth median space; the smaller, proximal pair more narrowly separated. These hairy elevations doubtless function as a cleaning brush, in which capacity they are supplemented by other less conspicuous patches of hair on the more distal parts of the oral surface. The proximal pair, which is decidedly asymmetrical, appears to be the homologue of the cleaning brush of Forficula, since it is similarly connected in front by a transverse arch, projecting inwards, the right and left parts of which are asymmetrical, the right bar projecting a little in front of the left where they meet in the middle line (cf. Forficula). These transverse bars represent the basal arch of the suspensorial apparatus, each being continuous with an irregular and unevenly sclerotized lateral bar, which, when traced towards its proximal end, is seen to expand into a broader plate, dividing distally into the mandibular and oral branches. On the whole, the form of the suspensorial apparatus has much in common with that of Forficula.

Ceuthophilus is similar to Gryllus in its hypopharynx except that it is much flatter, bilobed at apex, and the sclerotized and pigmented areas are simpler and less clearly defined. In most of these respects Ceuthophilus approaches Grylloblatta more closely than does Gryllus. It also resembles the Dictyopterous types considerably.

In Taeniopteryx (Pl. IV, Figs. 12 A, B, C) the hypopharynx is also bilobed and resembles the orthopterous forms just described in the V-shaped sclerite formed by the converging lateral bars, which are similarly expanded distally. It is also like Gryllus in the triangular profile. The integument is for the most part membranous, the apical and oral portions densely clothed with short hairs which are probably tactile. It bears no long lateral hairs such as occur in Forficula. The suspensorial bars are united mesially, where they form a pair of hairy elevations which probably serve as a cleaning brush. There is a stout mandibular branch on each side but the oral branches are extremely attenuated, and arise close together, being far removed from the mandibular branch. In this respect Taeniopteryx differs from the other types thus far described. Its hypopharynx approaches that of Grylloblatta more closely than does that of Forficula, but the resemblance to the Saltatoria is more apparent.

In Oligotoma (Pl. II, Figs. 7 A, B, C) the hypopharynx is strongly compressed and triangular in profile with a slight dorsal concavity at base. The oral surface is membranous with a marginal fringe of short, close-set hairs. Elsewhere the cuticle is, for the most part, thinly sclerotized, but there is a pair of definite, nearly parallel, ventrolateral bars and above these, in the proximal half, are broader but less clearly defined, lateral thickenings, which are nearly connected above with the outer ends of a transverse arch, formed of two narrowly separated and somewhat asymmetrical bars. Proximal to these is a second pair of asymmetrical sclerites which definitely belong to the suspensorial apparatus, since the mandibular branches arise from their outer extremities. Probably both arches represent parts of this apparatus. The mandibular branches are straight and slender and receive, at their basal extremities, the tendons of the superior protractor muscles.

The oral branches are extremely attenuated and arise together near the middle line, but appear to be disconnected with the basal arch. There is also a short row of setae just above each mandibular branch.

In the form of the suspensorial bars Oligotoma is most like Taeniopteryx, particularly in the median origin and feeble development of the oral branches. The lateral bars, separated from the suspensorial apparatus, and the membranous oral surface, are also suggestive of Taeniopteryx, although the general form of the organ is very different. It is also not unlike the hypopharynx of Termopsis (Pl. IV, Fig. 16 A, B, C) but in this form the oral branches of the suspensorial bars arise in common with the mandibular branches and are much better developed. Oligotoma shows but little resemblance to Grylloblatta, either in the form or the structure of its hypopharynx.

In Diapheromera (Pl. IV, Figs. 13 A, B, C) the hypopharynx is highly modified. Although resembling that of Oligotoma in the compressed form, it is but little like this genus or any of our other types in the sclerotized areas. Its rounded apical region is membranous and somewhat retractile and is, for the most part, covered with short, close-set hairs. The rest of the organ is covered by a fairly firm cuticle, which includes the parts distinguishable in other forms as the lateral bars and the transverse arch of the suspensorial apparatus. Definite ventrolateral bars are recognizable only for a short distance from the base, where they are united by a narrow transverse bar. The retractor muscles are inserted about the angles between the ventrolateral and transverse bars. In this respect Diapheromera resembles the Dictyoptera and Isoptera rather than the Saltatoria. Distally the ventrolateral bars are connected with the ventral extremity of a large sclerite, whose longitudinal axis is at right angles to that of the hypopharynx proper. It also articulates dorsally with the base of the latter and represents a part of the suspensorial apparatus, since it is continued at its upper extremity into the mandibular branch. This receives the tendon of the superior protractor muscle at its extreme apex, which is some distance above the general level of the hypopharynx. The oral branches arise from the hind margin of the dorsal sclerotized area, and are directed, like the mandibular branches, at right angles to the long axis of the organ as a whole. The oral branches are peculiar in being expanded into broad, wing-like processes, between which there is a deep trough.

The hypopharynx of Diapheromera is remarkably unlike that of any of our other types and shows no close affinity with that of Grylloblatta.

Turning to the Dictyopterous types we find, in Parcoblatta, (Pl. IV, Figs. 14 A, B, C) an almost parallel-sided hypopharynx, whose form is depressed in conformity with the general flattening of the head. The lateral bars are very distinct and do not encroach on the ventral surface except at the base, where they are bent inward to meet in the middle line at an angle. The ventral surface[9] is thinly sclerotized, while the

[9]We may term the two flattened surfaces dorsal and ventral for the sake of uniformity with other forms although they are not actually dorsal and ventral in position, owing to the peculiar position of the head in the Blattidae.

apex and most of the dorsal surface are membranous, the former bearing numerous, short, sensory hairs. The suspensorial apparatus consists of two curved, lateral plates, whose slender distal extremities curve inwards, meeting in the middle line, thus forming the basal transverse arch; while from the proximal extremities the two branches appear to arise together. Both branches are well developed, the mandibular being shorter, slightly thicker and more curved than the oral. The suspensorial bars are separated from the lateral bars by a slight interval, so that the basal girdle is broken on each side.

The hypopharynx of Stagmomantis (Pl. IV, Figs. 15 A, B, C) is very similar to that of Parcoblatta in its rectangular outline and sclerotized areas but differs in being less flattened, the profile showing a considerable dorsal convexity near the base, and in the absence of definite, converging, basal extremities of the lateral bars. The semi-membranous dorsal surface is raised in the form of a broad ridge and, towards the apex, is covered with short, sensory hairs as in Parcoblatta. The suspensorial bars are very similar to those of the latter, but the basal arch is less distinct since the thickening is below the general surface, and the oral branches are not so well defined as in Parcoblatta.

The hypopharynx of Termopsis (Pl. IV, Figs. 16 A, B, C) is essentially like the Dictyopterous types but is ovate in outline and deeper, with broader lateral bars, which, at the extreme base, are turned inward on the ventral surface, where they receive the fibres of the retractor muscles. Most of the ventral surface is thinly plated, the median portion of the proximal half being more membranous. Viewed from above the organ appears somewhat asymmetrical. It is but little sclerotized except at base, where the suspensorial bars join to form a transverse arch. These consist of two dorsolateral plates, from the narrowed proximal ends of which arise the two branches. The oral branches are strong and widely separated from one another as in the Dictyopterous forms; the mandibular branches are relatively slender, somewhat expanded at the distal extremity, on the upper angle of which is inserted the tendon of the superior protractor muscle.

As to the forms which Grylloblatta approaches most closely in the form and structure of the hypopharynx but little can be said. This organ in Grylloblatta is evidently simplified as regards both its sensory structure and its chitinous framework. In the lack of a dorsoapical membranous area, bearing sensory hairs, it differs from all of our other types. In the general character of its chitinous parts it approaches the Dictyoptera and Isoptera, but lacks the definite lateral bars that are found in these groups, except proximally, where they form the ventro-lateral V-shaped sclerite. Of the three types representing these groups, Termopsis is most like Grylloblatta in the outline of the hypopharynx, as seen from above or below, but the profile view shows it to be much thicker, this organ having in Grylloblatta a depressed form more like that of Parcoblatta.

THE MANDIBLES.

The form of the mandibles being largely dependent upon the character of the food is too variable to be of much phylogenetic value. Nevertheless they should not be omitted from our consideration.

In most orthopteroid insects the mandibles are slightly decurved, with a strongly incurved lateral margin, and are wedge-shaped from the broad base to the narrow apex and from the triangular outer surface to the inner margin. The latter is differentiated proximally into a short molar process, whose distal, projecting edge is sometimes modified into one or two teeth; and distally into two or three pointed incisors. The mandibles are typically, if not always, more or less asymmetrical, the molar processes often meeting one another obliquely and the incisors differing slightly in form and number and interlocking when the mandibles are closed.

For our purpose it will be sufficient to compare the mandibles of one side in each type, and we have arbitrarily selected the right. For the sake of brevity we have numbered the teeth as follows: 1, 2 and 3 are the incisors, beginning with the apical one, 4 is the prominent distal edge of the molar process, sometimes modified into a tooth, or two teeth, in which case they are designated 4a and 4b; 5 is the prominence at the proximal end of the molar process.

Of the chosen types Termopsis (Pl. V, Figs. 17 A, B) is most powerfully armed with teeth. The molar process is heavily sclerotized and very prominent at 5 (but not in the case of the left mandible), and its mesial surface is marked by a regular series of transverse ridges and grooves. Of the three incisors 1 and 2 are prominent and acute, 3 is low and blunt. There is more than the usual asymmetry in the mandibles, especially in the molar processes, which meet one another obliquely. In the soldier caste the mandibles are, of course, entirely different, being specialized as weapons of defense. They are long and falcate, without molar processes, but their characteristics need not be considered here.

In Parcoblatta (Pl. V, Figs. 18 A, B), which is not unlike Termopsis in the form of its mandibles, the molar process is relatively smaller and without the transverse ridges and grooves. Proximal to this process is a peculiar membranous lobe, which I failed to find in any of the other forms here considered but, according to Yuasa ('20), has a small representative in *Mantis religiosa* L. All three incisors are prominent and, in the left mandible, there are two or three smaller accessory ones.

Somewhat similar to these two forms in the arrangement of the teeth are the small mandibles of Taeniopteryx (Pl. V, Figs. 19 A, B). The molar process is well developed and there are three incisors, of which 2 is broader than the others and is flat and slightly notched. The mandibles in this form are very short as compared with their basal breadth.

Gryllus (Pl. V, Figs. 20 A, B) possesses stout mandibles of powerful structure, but the teeth are much less prominent than in the preceding genera. The molar process is relatively small and rounded, with

a concave mesial surface, and the three incisors are all rather blunt and rounded.

In Oligotoma (Pl. V, Figs. 21 A, B) the mandibles are small with only two incisors, although these are strongly developed, and the proximal one in the right mandible is partly overlapped by the molar process, which is short and narrow. That of the left mandible is larger and concave, the two meeting obliquely as in Termopsis and Parcoblatta.

In Forficula (Pl. V, Figs. 22 A, B) there are again but two incisors, apical and subapical in position. The cutting edge terminating in 2 is bent strongly ventrad at base, where it joins 4 (the distal prominence of the molar process) at its ventral angle, forming a sort of notch as seen in Fig. 22 B. The molar process is elongate and rather large.

Of the types thus far described Forficula is nearest Grylloblatta in the form of the mandibles. Those of Grylloblatta are, however, much longer and the molar process absent, being replaced by a cutting edge, and a blunt median tooth (4), which represents its distal extremity. There is a similar notch formed where the distal cutting edge joins the median tooth.

The mandible of Stagmomantis (Pl. V, Figs. 23 A, B) is most like that of Grylloblatta in general form, the presence of only two incisors and a median tooth (4), and in the absence of a molar process. The teeth are much larger, however, and the two incisors are divergent, as seen in mesial view. Incisor 2, which is in front of 1, is continuous with a long cutting edge, running obliquely more than half way to the base, there joining a short but prominent transverse ridge with a tooth at each end (4a and 4b.). This transverse ridge represents the distal prominence of the molar process, which is otherwise absent. The angle formed at the junction of the cutting edge and the transverse ridge represents the notch seen in Grylloblatta and Forficula.

Diapheromera is strikingly unlike all the other types in the form of the mandibles. They are remarkably stout with very broad bases, the dorsal and ventral articulations being very far apart. The mesial surface is also very short, broad and concave, being bounded dorsally by a hard, curved cutting ridge, and ventrally by a shorter and less prominent ridge. There are three stout teeth, of which the largest (1) is apical, while the other two are just proximal to it on the ventral margin. The broad mesial surface proximal to these teeth and including a part, at least, of the bounding margin is doubtless a modification of the molar process.

From the above comparisons few conclusions of phylogenetic significance can be drawn. The resemblance between the mandibles of Termopsis and Parcoblatta are probably due to the undoubted relationship which exists between the groups to which they belong, but the mantids, which are in some respects even nearer the blattids than are the Isoptera, have a very different type of mandible, a fact which is not surprising in view of their very different feeding habits. These habits are distinctly more specialized than those of the blattids and the mandible of the mantid must therefore be regarded as a more specialized type, as we should indeed conclude it to be on the basis of comparative morphology.

The mandible of Grylloblatta appears to be about intermediate between those of Forficula and Stagmomantis, but, while its special points of resemblance to the former may be due to relationship, its similarity to the mandibles of Stagmomantis must be regarded as a mere parallelism.

THE MAXILLAE.

When we compare the maxillae of Grylloblatta with those of the other genera selected we are perhaps first impressed with the similarity of the former to Forficula (Pl. VI, Fig. 25) in general form and in the form of the terminal lobes. The resemblance in the latter is particularly striking. The galea in both types is slender, flat and regularly falcate and is not hollowed to receive the lacinia. The laciniae show a like similarity of form but those of the earwig lack the basal tooth and the subapical spine is probably not homologous with that of Grylloblatta, since the latter is, in position, more nearly comparable to the third spine in such forms as *Gryllus*.

There are, however, in other respects important differences between the maxillae of Grylloblatta and Forficula. In the latter the articulatory condyle and basal arm of the cardo are widely separated, the former being larger and the latter smaller than in Grylloblatta. The ridge of the cardo runs from the distomesial angle to the basal arm, the mesial part of the cardo having a triangular form. The primitive divisions of the stipes have disappeared, the mesial area having become membranous. Secondary sutures divide the stipes as shown in Fig. 24. Greater specialization is noticeable in the relative lengths of the palpal segments.

The maxilla of the Saltatoria, as represented by Gryllus (Pl. VI, Fig. 26), although not quite so much like that of Grylloblatta as is that of Forficula in general form and in the terminal lobes, is really more like it in most essential respects. The cardo and stipes show no important differences except that the palpifer is much more distinct. The galea is broader and thicker and overtops the lacinia, which has three distal hooks instead of two, but lacks the basal tooth. The palpi are considerably longer, but palpal length is an exceedingly variable feature in the Orthoptera.

The Dictyoptera and Isoptera (Pl. VI, Figs. 27–29) again show their relationship to one another in the structure of the maxillae. They all show the typical division of cardo and stipes with no very striking differences. The mesial area of the cardo is large in all and in the Dictyoptera has a broad base with a well-developed basal arm but no distinct articulatory condyle. The ridge of the cardo joins the outer margin in Termopsis (Fig. 27.) and Parcoblatta (Fig. 28.). The terminal lobes are rather similar in all these forms. The galea is thick and membranous and grooved for the reception of the lacinia. The latter has a strongly convex inner margin, thickly beset with bristles and terminating in only two hooks. All of them lack the basal tooth of Grylloblatta. The chief differences are in the palpi. In Parcoblatta and Termopsis the first two joints are short, the others much longer and

enlarged distally. This is particularly true of the terminal segment in Parcoblatta, which is considerably enlarged and has a specialized mesial surface covered with sensillae. The palpus of Stagmomantis (Fig. 29) is strikingly different, being comparatively short and slender, the second joint twice as long as the first, and the last two segments scarcely longer than the third and neither enlarged nor with a specialized sensory area.

The maxilla of Oligotoma (Pl. VI, Fig. 30) resembles those of the Isoptera and Dictyoptera more than those of Grylloblatta or Gryllus in the form of the lacinia with its convex inner margin, strong marginal bristles and terminal hooks. The galea is narrower but is slightly hollowed for the reception of the lacinia. The subdivisions of the cardo and stipes are typical. The articulatory condyle and basal arm of the cardo are well separated, as in the Dictyoptera.

The maxillae of Taeniopteryx (Pl. VI, Fig. 31) are not unlike those of Grylloblatta, but differ in the following points:—The cardinal ridge is even more strongly curved and is divided basally into two branches, enclosing an area which includes the much shorter basal arm. The area laterad of the ridge is strongly convex and prominent. The palpifer forms with the subgalea a single, somewhat membranous sclerite, separate from the remaining part of the stipes by an oblique suture. This appears to be a primitive condition suggestive of the Thysanuran family Machilidae. The terminal lobes are well developed and resemble those of the Orthoptera. The lacinia has a triangular mesial surface and a pair of rather large terminal hooks. The palpi are fairly large and stout with no great elongation of any of the segments.

Diapheromera (Pl. VI, Fig. 32) has a comparatively small maxilla, which resembles that of Taeniopteryx in general appearance and more particularly in the form of the palpus and cardo. The latter is similarly divided by a strongly curved and branched ridge and the lateral area is even more prominent. The articular margin is broadly rounded and the basal arm is well developed but does not project so far inward as usual. The stipital suture is oblique and the lateral area of the stipes shorter than the mesial, very prominent, and separated from the palpifer by a deep groove. The galea bears a large lateral lobe near the base and terminates in a somewhat sclerotized apex bearing a small tooth. The lacinia is broad and triangular, with a spiny inner margin and a terminal tooth, whose mesial surface is concave and whose lower margin bears a small denticle. The palpal segments are stout and gradually increase in length distad, none being, however, much elongated.

On the whole the maxilla of Grylloblatta is most like that of the Saltatoria, followed by the Dictyoptera and Isoptera. No very important differences, however, exist among any of the selected types, the most noteworthy being the absence in Forficula of the stipital suture and the presence of secondary sutures not found in other forms. None of our types have the acute basal tooth on the lacinia present in Grylloblatta but sometimes there is an angular prominence, as in many Locustidae.

THE LABIUM.

The structure of the labium of Grylloblatta seems to be in keeping with its other primitive features since it combines characteristics of the more generalized Saltatoria with those of the Dictyoptera and Isoptera. In the labium of Gryllus (Pl. VII, Fig. 34) or Ceuthophilus the submentum is remarkably like that of Grylloblatta, being elongate, without a gula, but with a well developed and freely moveable distal plate. The mentum is practically entire, the two labial stipites being more completely united than in Grylloblatta. The paraglossae and glossae are well developed but the latter are usually smaller and crowded dorsally, being more or less concealed by the overlapping paraglossae, which are broader than in Grylloblatta. The paraglossae are more distinctly marked off from the mentum and more strongly bent or curved, a transverse crease appearing in the concave or mesial side, which partly divides the lobe into two segments. This division is more marked in Gryllus than in Ceuthophilus and the proximal segment suggests a homology with the subgalea of the maxilla, but, unlike the latter, appears to belong to the paraglossa itself (galea) rather than the stipes. The palpigers in Gryllus are distinctly defined, but are only feebly indicated in Ceuthophilus.

In the Locustidae (Acrididae) the labium is more specialized and resembles that of Grylloblatta much less closely. The submentum is smaller, the secondary plate both short and narrow and fused with the mentum, so that the latter is not retractile. The glossae are also vestigial, devoid of muscles, and usually concealed by the huge, scoop-like paraglossae. The palpigers are sometimes very prominent.

In the Dictyoptera and Isoptera (Pl. VII, Figs. 35–37) the submentum is less like that of Grylloblatta than in the primitive Saltatoria in that its two sclerites are fused and the dividing suture sometimes disappears. The terminal lobes, on the other hand, are more like those of Grylloblatta than the Saltatoria, since they are more nearly equal in size and lie in the same plane, the glossae being fully exposed. The paraglossae are also simple like those of Grylloblatta, and the palpigers, as in the latter, are not distinct. In the Blattidae the secondary submental plate is well defined, but tends to become enclosed by the forward curvature, on each side, of the primary plate, with which it is ankylosed (Fig. 35). The mentum is large and may be slightly divided distally. In Stagmomantis (Fig. 36) and other Mantidae the secondary submental plate has lost its identity, no suture remaining to mark its separation from the primary submentum. The glossae are fully as long and as thick as the paraglossae. Termopsis (Fig. 37) is like the mantids in having but one submental sclerite, but, in Eutermes, although only one sclerite is present, there is a narrow, distal, membranous zone which renders the submentum indistinguishable from the primitive type. In the soldier caste of Termopsis, and doubtless other genera, the great elongation of the head is accompanied by a corresponding lengthening of the submentum in the region of the posterior tentorial pits, which are drawn out into suture-like slits. This part of the

submentum is firmly united with the head capsule, only a small part of its anterior end being free. There is, however, no separation of a posterior or gular region. In other respects the Isopteran labium is much like that of Grylloblatta, although the terminal lobes are smaller.

In Forficula (Pl. VII, Fig. 38) and Anisolabis the general form of the labium recalls strongly that of Grylloblatta, which it also resembles in the median cleft of the mentum, although the cleft is even deeper than in that genus. As a result of this deep cleft the labial apodeme projects into the region covered by the secondary submental plate, which is distinct and free, though short. The dermapterous labium further differs from all the other types here considered in having only one pair of terminal lobes, which appear like a fusion of paraglossa and glossa, but probably represent the former alone. The palpi are remarkable for the extreme shortness of the first segment and for the site of origin of the flexor muscle of the terminal segment, which arises on the posterior wall of the second segment, instead of the anterior side of the base of the first segment.

The presence of a distinct guliform plate immediately behind the submentum and the posterior tentorial pits is another striking dermapteran feature, but this certainly does not represent a part of the submentum.

Among the Plecoptera we find, in the nymph of Pteronarcys (Pl. VI, Fig. 33), a strikingly primitive Orthopteroid labium, as noted by Hoke ('24). The resemblance in this form to Grylloblatta is remarkable indeed, as can be seen by the comparison of the figures. In Taeniopteryx (Pl. VII, Fig. 39), which, in the sum of its characters, is more primitive than Pteronarcys, the resemblance is not so great and yet the differences consist in little save the proportions of parts. The submental plates are much shorter, the terminal lobes are more membranous and unequal in size, the paraglossae being much broader and the glossae relatively smaller. In the specialized Plecoptera, such as the Perlidae, these differences are more exaggerated. In the nymph to Perla, e. g., the labium is very broad as compared with its length. The secondary submental plate is very short and tends to become enclosed by the forwardly projecting lobes of the huge primary submentum. The terminal lobes are short, broad, and membranous, the paraglossae being much the larger.

The labium of Oligotoma (Pl. VII, Fig. 40) is also truly orthopteroid, the gula in this form being certainly not derived from the submentum and thus having nothing to do with the labium. The primary submentum is well developed, the secondary plate small but free and not reaching the lateral margin of the labium. The mentum is large and undivided with no distinct demarcation of the palpigers. The paraglossae are broad and meet one another distally, while the glossae are small and very slender.

Finally, in Diapheromera (Pl. VII, Fig. 41) we find a labium that is peculiar in several respects. Although the entire appendage is somewhat elongated, the submentum is less so than would be expected in a prognathous insect of such attenuated form. The primary plate has a

transverse flexible area across the middle and there is also complete freedom of movement between the primary and secondary plates, or what appears to be the latter. This is the constricted region just proximal to the palpigers, but, since it is fused with the latter and the mentum, it might be interpreted as belonging to the latter region. The insertion of the median retractor muscles might have been expected to decide this question, but they have evidently shifted from their usual position (proximal edge of mentum), since they are inserted in the middle part of the mentum, altogether distal to the palpigers. This shifting is probably of mechanical advantage, owing to the unusual length of the mentum and paraglossae. The line of insertion of these muscles is indicated externally by a short secondary suture.

The labium of Grylloblatta is most like that of the primitive Saltatoria but in some respects approaches the Isoptera-Dictyoptera group more closely. The most important modifications of the primitive type which it represents are found in Forficula and Diapheromera.

SUMMARY.

Head capsule.—The head capsule of Grylloblatta resembles in general form that of Forficula, Oligotoma, Taeniopteryx and Termopsis. It is very close to Forficula, but the absence of a guliform sclerite is an important difference. It is less like Oligotoma in general form and in other characters, such as the occipital suture and in the fact that the guliform plate of Oligotoma has, by fusion, become virtually a part of the head capsule itself. Termopsis differs in having a perforate tentorium but otherwise resembles Grylloblatta rather closely.

Parcoblatta and Stagmomantis differ from Grylloblatta not only in the perforate tentorium and other details of its structure but also in other features correlated with differences in the position in which the head is held, such as the shortening and flexure of the postocular tergal region. The sum of differences in Stagmomantis is very considerable but largely of an adaptive nature.

Gryllus and Ceuthophilus are very similar to Grylloblatta in the structure of the head capsule, differing mainly in those characters which are associated with the change from a prognathous to a hypognathous condition. These characters are adaptive and of relatively little phylogenetic importance though distinctive of the Saltatoria as a whole, except in special cases such as the fossorial Gryllotalpidae.

Antennae.—The antennae of Grylloblatta are similar to those of Oligotoma and Termopsis in the number of segments

and nearest to Oligotoma in their form. In Forficula the segments are fewer but their form is not very different except in the basal segments. In the other genera described the antennae are much longer, the segments more numerous, and the intersegmental constrictions less marked when present at all. The number of segments is, however, of little significance, since it varies greatly within most of the groups.

Hypopharynx.—In this organ Grylloblatta combines features of Termopsis, Parcoblatta, and Ceuthophilus, but it differs from all in the lack of a membranous distal area bearing sensillae, and shows other marks of a simplified structure. Taeniopteryx comes next, while the other forms are more or less strikingly different, especially Diapheromera and Forficula. The last-named genus differs from all the others in possessing lateral lobes, which are probably vestigial superlinguae.

Mandibles.—The mandibles of Grylloblatta differ from those of all the other forms except Stagmomantis and the soldier caste of Termopsis in their greater proportional length and the lack of a molar surface. They are somewhat like those of the mantid in general form, but are probably nearer those of Forficula. They are least like the mandibles of Diapheromera and differ from the other forms except Oligotoma, having only two instead of three or more incisor teeth.

Maxillae.—The maxillae of Grylloblatta are very similar to those of Gryllus and Ceuthophilus, differing mainly in having a strong basal lacinial tooth and only one preapical tooth. They also resemble the maxillae of Termopsis, Parcoblatta and Stagmomantis except in details of the terminal lobes. In the form of these parts and the appendage as a whole Forficula is very like Grylloblatta, but the absence of the primitive stipital suture and the presence of secondary sutures places it somewhat apart from all the other types. Oligotoma and Taeniopteryx show only minor differences, such as the shorter, stouter palpi of the former and the well-marked palpifers of the latter. Diapheromera has in some respects the least typical maxillae. They differ from the other forms in the large basal arm of the cardo, the basal lobe and hard tooth-like tip of the galea, and, as compared with Grylloblatta, the small relative size of the appendage as a whole.

Labium.—The labium of Grylloblatta combines features of Gryllus or Ceuthophilus with those of Termopsis and the

Dictyoptera, being strikingly like the first two in the presence of a large and freely moveable secondary submentum. Next to these forms come Oligotoma and Taeniopteryx, but in these the secondary submentum and the glossae are reduced, while the paraglossae are much broader. The labium of Forficula resembles that of Grylloblatta in relative size and general form, and in the cleft mentum, but differs in the absence of glossae, the inequality of the palpal segments with important differences in their musculature. The labium of Diapheromera is peculiar in the transverse division of the primary submentum, the fusion of the secondary submentum with the mentum, while remaining free from the primary plate, the distal shifting of the insertions of the median retractor muscles, and the elongation of the paraglossae. It is one of the most modified of all the types described.

GENERAL CONCLUSIONS

In its head and appendages Grylloblatta is nearest the Saltatorial Orthoptera, though possessing a more primitive form of head capsule. As far as these parts are concerned Grylloblatta almost exactly fits the hypothetical concept of a common ancestor for the Saltatoria and the Dermaptera. It is only in the hypopharynx and mandibles, and of course the reduction of the compound eyes and lack of ocelli that any essential difference need be assumed in the ancestral form. The hypopharynx of Grylloblatta is doubtless somewhat degenerate. The presence of superlinguae in the Dermaptera, if the lateral lobes are to be interpreted as such, is a primitive feature, retained in this order only, among the groups here considered. It is, however, by no means certain that these lobes are true superlinguae. The lack of molar processes on the mandibles of Grylloblatta is also a modification of the primitive condition, since these processes are rarely absent in the orthopteroid groups.

The plecopteran head may also be derived from a form similar to that of Grylloblatta, for, although in the majority of the order the head and its appendages are considerably different from this type, that of such undoubtedly primitive forms as Taeniopteryx closely resemble it. The small mandibles and associated characters are clearly the initial stages of a condition which is more pronounced in the higher Plecoptera.

The embiopteran head may equally well be derived from the same ancestral type, the important differences, such as the guliform plate, being evidently of a secondary nature.

Even Diapheromera, in spite of its lack of close agreement with Grylloblatta in any of its parts, shows no features which may not be readily derived from an ancestor resembling Grylloblatta. The more primitive phasmids, such as Timema, will probably be found to resemble this type more closely.

The remaining forms are clearly related to one another and one of them, Termopsis, has the same general type of head as Grylloblatta except in the perforate tentorium. Since the imperforate tentorium occurs in all the other groups, as well as such other primitive orders as the Ephemeroptera, it may be considered as the more archaic of the two types of tentorium. Hence these groups may also be traceable to a grylloblattoid ancestor, in so far as the head is concerned.

It must not be assumed, however, that Grylloblatta is necessarily closely akin to the common ancestor of the orthopteroid orders because of the head characters alone. We may at present merely conclude that its head is essentially like that of the ancestor of these groups. Such an ancestor doubtless differed from Grylloblatta in having larger and better developed eyes, three ocelli, mandibles with molar processes, and a more complex hypopharynx.

BIBLIOGRAPHY.

Basch, S. 1865. Untersuchungen über das Skelet und die Muskeln des Kopfes von Termes flavipes. Zeit. Wiss Zool., 15: 56–75.

Berlese, A. 1909. Gli Insetti. I. Milan.

Borner, C. 1909. Neue Homologien zwischen Crustaceen und Hexapoden. Die Beissmandibeln der Insekten und ihre phylogenetische Bedeutung. Zool. Anz., 34: 100–125; 9 Figs.

Comstock, J. H. and **Kochi, C.** 1902. The skeleton of the head of insects. Amer. Nat., 36: 13–45; 29 Figs.

Crampton, G. C. 1915. The thoracic sclerites and systematic position of Grylloblatta campodeiformis Walker, a remarkable annectant "orthopteroid" insect. Ent. News, 26: 337–350, Pl. 13.

1916. A comparative study of the maxillae of the Acridiidae (Oedipodinae and Tettiginae), Phasmidae and Phylliidae. Psyche, 23: 83–87, Pl. 11.

1917a. A comparison of the antennae of the Grylloblattidae and Embiidae to demonstrate the relationships of these two groups of insects. Can. Ent., 49: 213–217.

1917b. A phylogenetic study of the lateral head, neck, and prothoracic regions in some Apterygota and lower Pterygota. Ent. News, 28: 398–412.

1920a. Notes on the lines of descent of the lower winged insects. Psyche, 27: 116–127.

1920b. Some anatomical details of the remarkable winged Zorapteron, Zorotypus hubbardi Caudell, with notes on its relationships. Proc. Ent. Soc. Wash., 22: 98–106, Pl. 7.
1921a. The sclerites of the head, and the mouth-parts of certain mature and adult insects. Ann. Ent. Soc. Amer., 14: 65–103, Pls. 2–8.
1921b. The origin and homologies of the so-called "superlinguae" or "paraglossae" (paragnaths) of insects and related arthropods. Psyche, 28: 84–92, Pl. 5.
1922. The derivation of certain types of head capsule in insects from Crustacean prototypes. Proc. Ent. Soc. Wash., 24: 153–158, 1 Pl.
1925. The external anatomy of the head and abdomen of the roach, Periplaneta americana. Psyche, 32: 195–220, Pls. 5–7.
1926. The affinities of Grylloblatta indicated by a study of the head and its appendages. Psyche, 33: 78–84.
1927. The abdominal structures of the orthopteroid family Grylloblattidae and the relationships of the group. Pan-Pacific Ent., 3: 115–135.
1928a. The eulabium, mentum, submentum and gular region of insects. Journ. Ent. Zool., 21: 115, 3 Pls.
1928b. The evolution of insects, chilopods, diplopods, Crustacea and other Arthropods indicated by a study of the head capsule. Can. Ent., 60: 129–141, Pls. 8–12.
1932. A phylogenetic study of the head capsule in certain orthopteroid, psocoid, hemipteroid and holometabolous insects. Bull. Brooklyn Ent. Soc., 27: 19–56, Pls. 4–7.

Duporte, E. M. 1920. The muscular system of Gryllus assimilis Fabr. Ann. Ent. Soc. Amer., 13: 16–52, Pls. 1–7.

Handlirsch, A. 1908. Die fossilen Insekten und die Phylogenie der rezenten Formen. Lempzig. 1430 pp., 47 Pls.

Hansen, H. J. 1893. Zur Morphologie der Gliedmassen und Mundtheile bei Crustaceen and Insekten. Zool. Anz., 16: 193–198, 201–212.
1930. Studies on Arthropoda, III. Copenhagen. 375 pp., 16 Pls.

Henriksen, K. L. 1929. Contribution to the interpretation of the cephalic segments of Arthropoda. Trans. 4th Internat. Cong. Ent., Ithaca: 589–594.

Hoke, Gladys. 1924. The anatomy of the head and mouthparts of the Plecoptera. Journ. Morph., 38: 347–373, 6 Pls.

Imms, A. D. 1929. A General Textbook of Entomology. Second Edition; 703 pp.
1927. On the affinities of the Grylloblattidae. Psyche, 34: 36–39.

MacGillivray, A. D. 1923. External Insect Anatomy. Urbana, Ill. 388 pp.

Mangan, J. 1908. On the mouth-parts of some Blattidae. Proc. R. Irish Acad., 27; B: 1–10, Pls. 1–3.

Snodgrass, R. E. 1928. Morphology and evolution of the insect head and its appendages. Smiths. Misc. Coll., 81: No. 3, 158 pp., 57 Figs.

Stickney, F. S. 1923. The head capsule of Coleoptera. Illinois Biol. Monog., 8: No. 1: 51 pp., 26 Pls.

Walker, E. M. 1931a. On the clypeus and labrum of primitive insects. Can. Ent., 63: 75–81, Pl. 6.
1931b. On the anatomy of Grylloblatta campodeiformis Walker. I. Exoskeleton and musculature of the head. Ann. Ent. Soc. Amer., 24: 519–531, 4 Pls.
1932. Prognathism and hypognathism in orthopteroid insects. Can. Ent. 64: 223–229, Pl. 7.

Wu, C. F. 1923. Morphology, anatomy and ethology of Nemoura. Bull. Lloyd Library, 23, Ent. Ser. 3, 81 pp., 16 Pls.

Yuasa, H. 1920. The anatomy of the head and mouth-parts of Orthoptera and Euplexoptera. Journ. Morph., 33: 251–290. 9 Pls.

EXPLANATION OF PLATES.*

PLATE I.

Fig. 1. *Forficula auricularia* L., head capsule with left mandible in situ. 1A, dorsal view; 1B, left lateral view; 1C, ventral view.
Fig. 2. *Oligotoma hospes* Myers, head capsule with left mandible in situ. 2A, dorsal view; 2B, left lateral view; 2C, ventral view.
Fig. 3. *Taeniopteryx nivalis* Fitch, head capsule with left mandible in situ. 3A, dorsal view; 3B, left lateral view; 3C, ventral view.

PLATE II.

Fig. 4. *Diapheromera femorata* Say, head capsule, with left mandible in situ. 4A, anterior view; 4B, left lateral view; 4C, posterior view.
Fig. 5. *Gryllus assimilis* Fabr., head capsule with left mandible in situ. 4A, dorsal view; 4B, left lateral view; 4C, ventral view.
Fig. 6. *icularia Forficula aur* L., hypopharynx. 6A, dorsal view; 6B, left lateral view; 6C, ventral view.
Fig. 7. *Oligotoma hospes* Myers, hypopharynx. 7A, dorsal view; 7B, left lateral view; 7C, ventral view.

PLATE III.

Fig. 8. *Termopsis angustipennis* Hagen., head capsule with left mandible in situ. 8A, dorsal view; 8B, left lateral view; 8C, ventral view.
Fig. 9. *Parcoblatta pensylvanica* DeG., head capsule with left mandible in situ. 9A, dorsal view; 9B, left lateral view; 9C, ventral view.
Fig. 10. *Stagmomantis carolina* Johann., head capsule with left mandible in situ. 10A, dorsal view; 10B, ventral view.

PLATE IV.

Fig. 11. *Gryllus assimilis* Fabr., hypopharynx. 11A, dorsal view; 11B, left lateral view; 11C, ventral view.
Fig. 12. *Taeniopteryx nivalis* Fitch., hypopharynx. 12A, dorsal view; 12B, left lateral view; 12C, ventral view.
Fig. 13. *Diapheromera femorata* Say, hypopharynx. 13A, dorsal view; 13B, left lateral view; 13C, ventral view.
Fig. 14. *Parcoblatta pensylvanica* DeG., hypopharynx. 14A, dorsal view; 1Bb, left lateral view; 14C, ventral view.
Fig. 15. *Stagmomantis carolina* Johann., hypopharynx. 15A, dorsal view; 15B, left lateral view; 15C, ventral view.
Fig. 16. *Termopsis angusticollis* Hag., hypopharynx. 16A, dorsal view; 16B, left lateral view; 16C, ventral view.

PLATE V.

Fig. 17. *Termopsis angusticollis* Hag., right mandible. 17A, ventral view; 17B, mesial view.
Fig. 18. *Parcoblatta pensylvanica* DeG., right mandible. 18A, ventral view; 18B, mesial view.
Fig. 19. *Taeniopteryx nivalis* Fitch, right mandible. 19A, ventral view; 19B, mesial view.
Fig. 20. *Gryllus assimilis* Fabr., right mandible. 20A, ventral view; 20B, mesial view.
Fig. 21. *Oligotoma hospes* Myers, right mandible. 21A, ventral view; 21B, mesial view.
Fig. 22. *Forficula auricularia* L., right mandible. 22A, ventral view; 22B, mesial view.
Fig. 23. *Stagmomantis carolina* Johann., right mandible. 23A, ventral view; 23B, mesial view.
Fig. 24. *Diapheromera femorata* Say, right mandible. 24A, ventral view; 24B, mesial view.

*For figures of Grylloblatta, see Walker, 1931b.

PLATE VI.

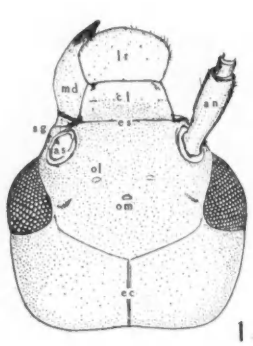
Fig. 25. *Forficula auricularia* L., left maxilla.
Fig. 26. *Gryllus assimilis* Fabr., left maxilla.
Fig. 27. *Termopsis angusticollis* Hag., left maxilla.
Fig. 28. *Parcoblatta pensylvanica* DeG., left maxilla.
Fig. 29. *Stagmomantis carolina* Johann., left maxilla.
Fig. 30. *Oligotoma hospes* Myers, left maxilla.
Fig. 31. *Taeniopteryx nivalis* Fitch, left maxilla.
Fig. 32. *Diapheromera femorata* Say, left maxilla.
Fig. 33. *Pteronarcys dorsata* Say, labium of last nymphal instar.

PLATE VII.

Fig. 34. *Gryllus assimilis* Fabr., labium.
Fig. 35. *Parcoblatta pensylvanica* DeG., labium.
Fig. 36. *Stagmomantis carolina* Johann., labium.
Fig. 37. *Termopsis angusticollis* Hag., labium.
Fig. 38. *Forficula auricularia* L., labium.
Fig. 39. *Taeniopteryx nivalis* Fitch, labium.
Fig. 40. *Oligotoma hospes* Myers, labium.
Fig. 41. *Diapheromera femorata* Say, labium.

ABBREVIATIONS.

ab.—tendon of mandibular abductor.
acl.—anteclypeus.
ad.—tendon of mandibular adductor.
af.—antennifer.
an.—antenna.
as.—antennal socket.
at.—anterior arms of tentorium.
cb.—cleaning brush of hypopharynx.
cda.—basal arm of cardo.
cdr.—cardinal ridge.
cl.—clypeus.
cv.—occipital condyle.
dt.—dorsal arm of tentorium.
ec.—epicranial suture.
es.—epistomal suture.
fg.—frontogenal suture.
g.—galea.
gl.—glossa.
gu.—guliform plate.
hb.—ventrolateral bar of hypopharynx.
hp.—tendon of mandibular protractor muscle of hypopharynx.
hr.—retractor muscle of hypopharynx.
hs.—suspensorial apparatus of hypopharynx.
hsm.—mandibular branch of same.
l.—lacinia.
lr.—labrum.
m.—mentum.
mc.—mandibular condyle.
md.—mandible.
mxc.—maxillary condyle.
oc.—occipital suture.
ol.—lateral ocellus.
om.—median ocellus.
pcl.—postclypeus.
pf.—palpifer.
pg.—palpiger.
pl.—paraglossa.
poc.—postoccipital suture.
pp.—posterior tentorial pits.
pt.—posterior arms of tentorium.
rx.—"radix" of hypopharynx.
sd.—salivary duct.
sg.—subgenal suture.
sm.—primary submentum.
sm.—secondary submentum.
spg.—superlinguae.
str.—stipital suture or ridge.
t.—body of tentorium.
ta.—anterior bridge of tentorium.
tm.—torma.
tp.—posterior bridge of tentorium.
vpl.—ventral plate of hypopharynx.



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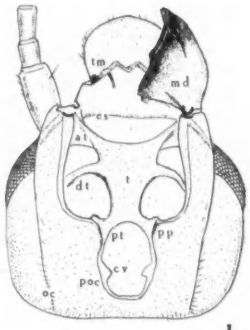

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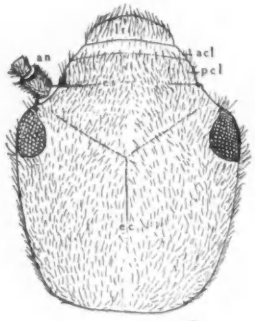

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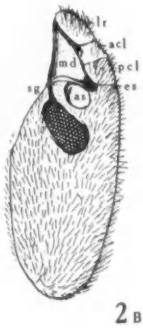

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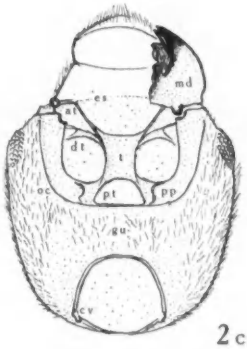

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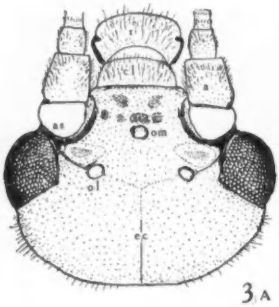

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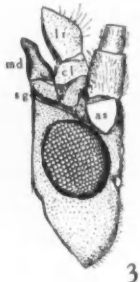

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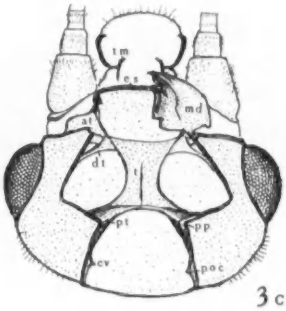

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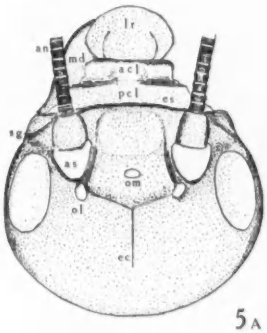

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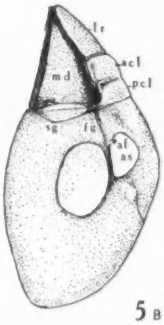

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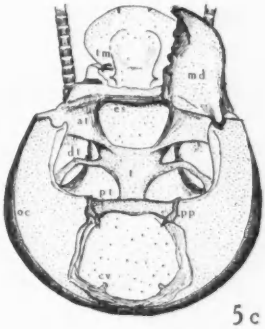

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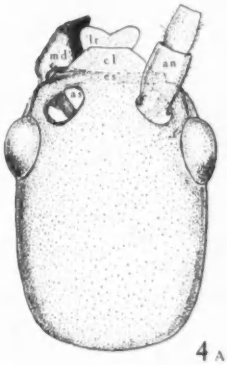

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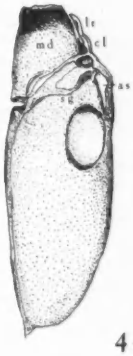

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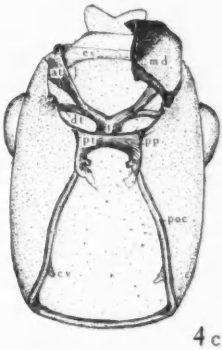

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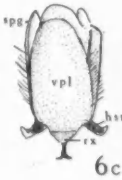

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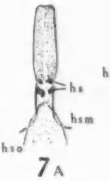

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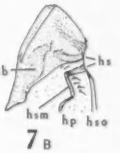

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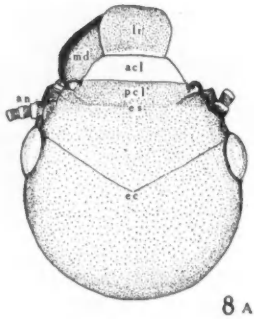

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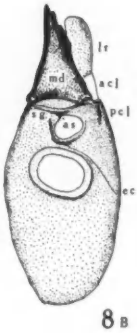

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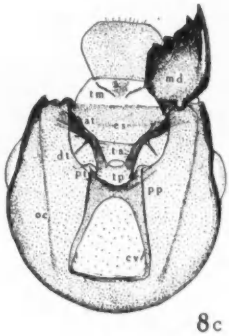

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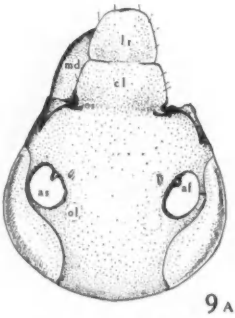

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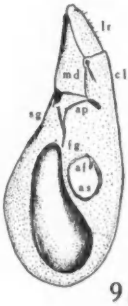

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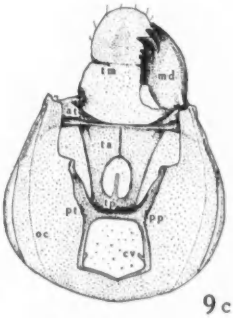

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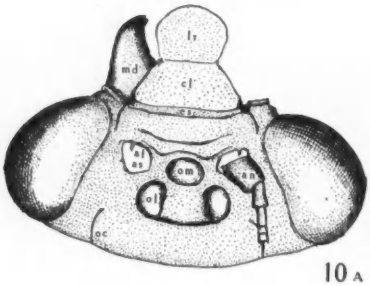

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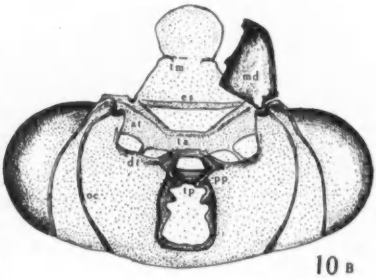

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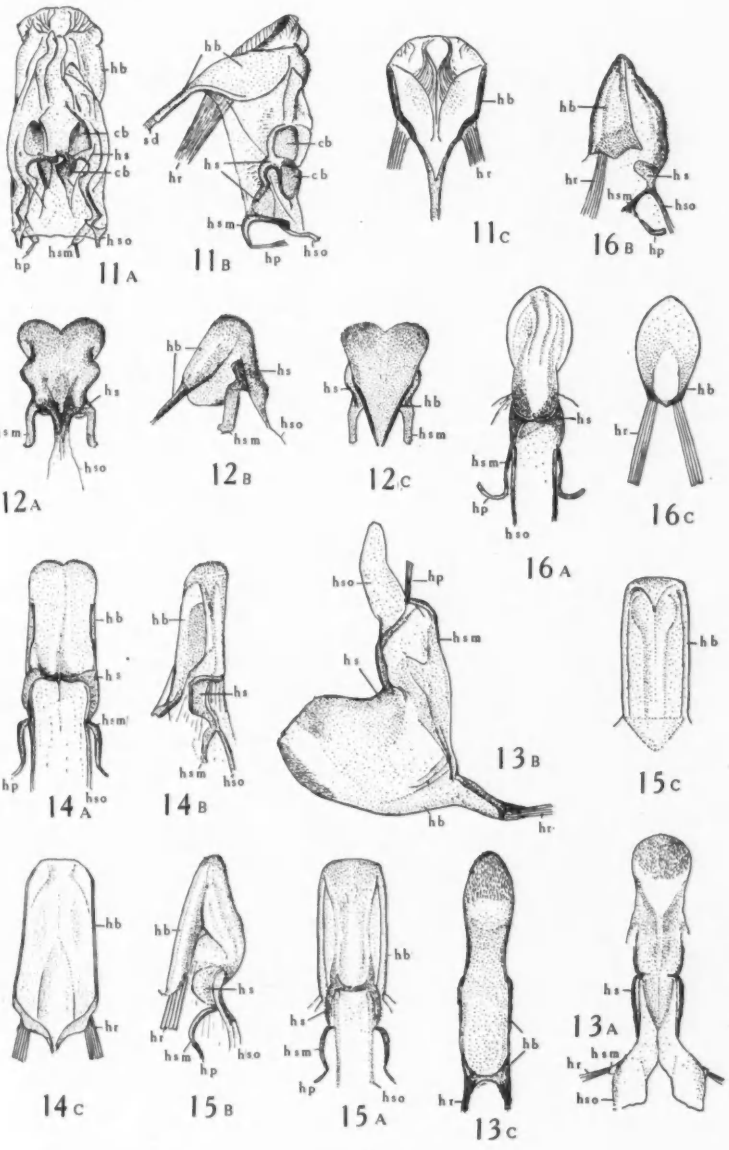
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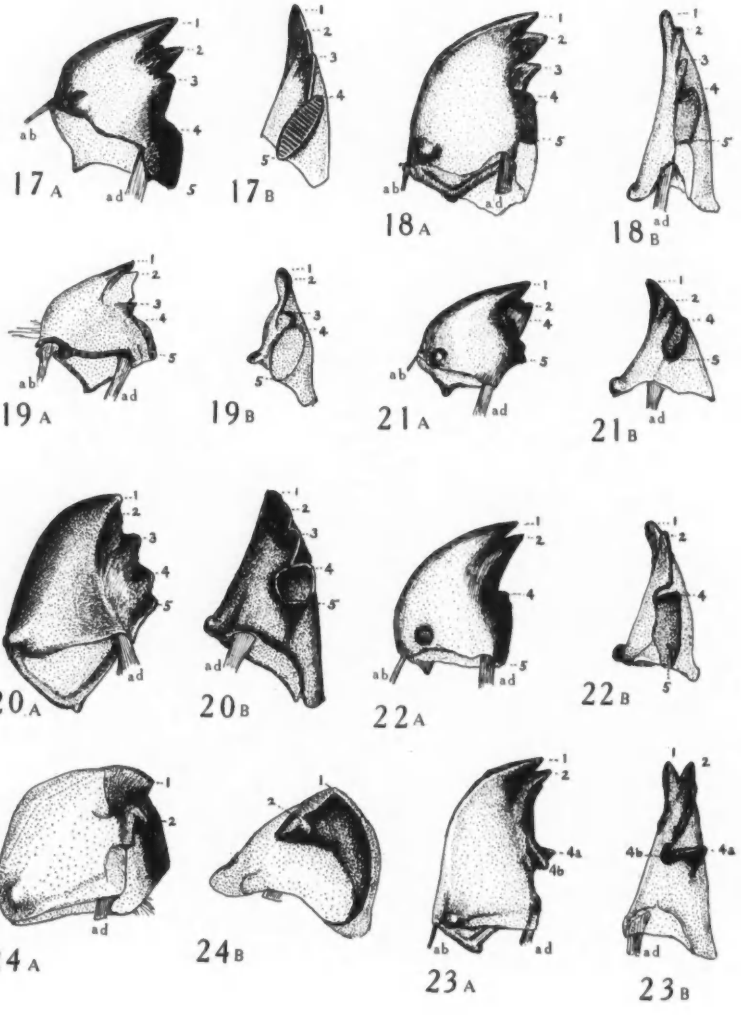
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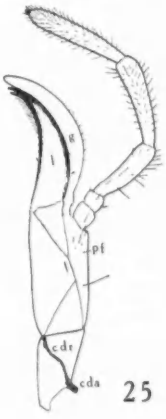

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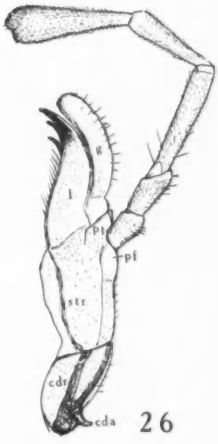

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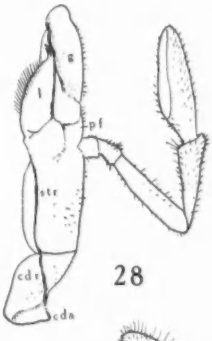

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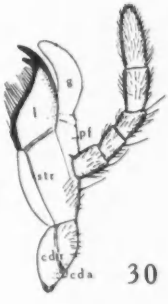

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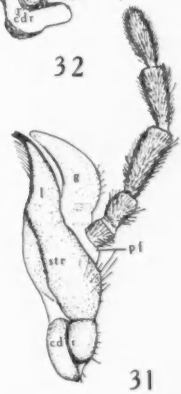

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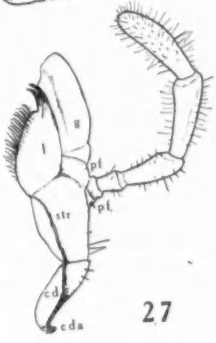

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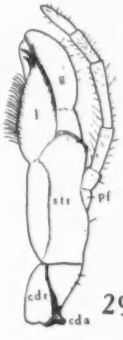

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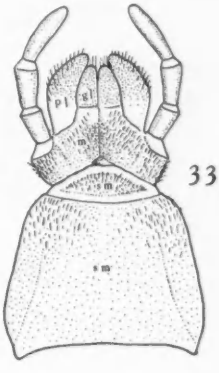

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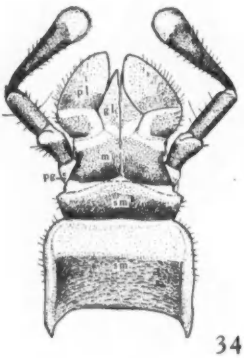

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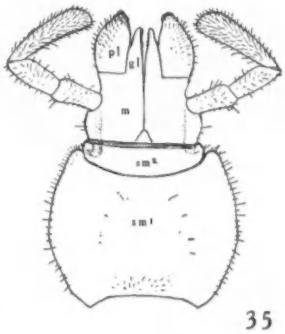

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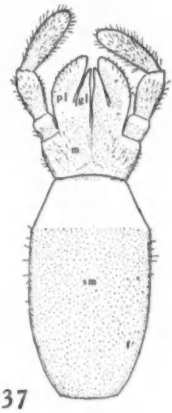

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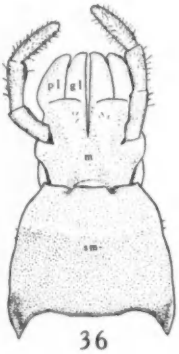

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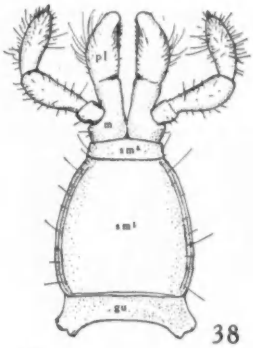

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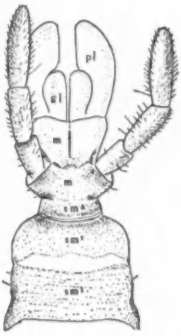

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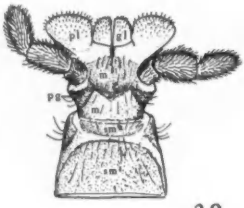

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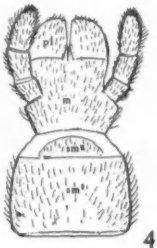

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UNUSUAL VARIATION IN THE LIFE CYCLE OF THE MALE OF AENOPLEX CARPOCAPSAE CUSH., CODLING MOTH PARASITE.

H. ELLIOTT MCCLURE,
Urbana, Illinois.

Studies of *Aenoplex carpocapsae* Cush., a parasite of the codling moth, *Carpocapsa pomonella* Linne, conducted in Illinois during 1931, showed that there existed marked differences in the lengths of life cycles, for different individuals, according to their parentage. The adult parasites were taken from untreated corrugated paper codling moth bands on apple trees in Calhoun County. As only a few males were found at that time the females were unfertilized. These unfertilized females actively parasitized the full grown spinning codling moth larvae given them and the male progeny produced had strikingly different life cycles.

Codling moth larvae having spun up in short lengths of corrugated paper were stung by the parasites. The parasites laid one egg each in all the host cases, the eggs being laid upon or beside the immotile hosts. After a time the parasites were removed from the host larvae and one parasite egg and a codling moth larva were placed in lengths of one-fourth inch glass tubing. In this way careful studies could be made throughout the life of the ectoparasitic parasite.

Upon finding a cocoon of the codling moth larva the female *Aenoplex* first probes it carefully with her ovipositor and then with one quick jab stings the insect within and lays the egg. The host larva is stung at random, wherever the cocoon is penetrable, and the egg laid at the place of the sting. The duration of the egg stage is about 54 hours, or a little over two days.

When the larva hatches it feeds at random upon the paralyzed codling moth larva for a period between four and one-half and eight and one-half days. Feeding is accomplished by rasping the skin of the host and sucking the inner contents. No direct break is made in the body wall of the host until the parasite larva is nearly full grown. Two types of parasite larvae become apparent as they grow older; one which averages

five to six millimeters in length when full grown and the other six to eight millimeters. The smaller type of larva only partially devours the host, while the larger type leaves only the head and a bit of dried skin. As the chart shows there is but little difference, about a day, in the average length of life of the larvae.

The parasite larva, when full grown, spins a cocoon of onion-skin texture about itself, excluding the remains of the host, within the codling moth larva's cocoon. The cocoons of both types are about one centimeter long. Those of the smaller type are oval, while those of the larger type are quadrilateral or rhomboid.

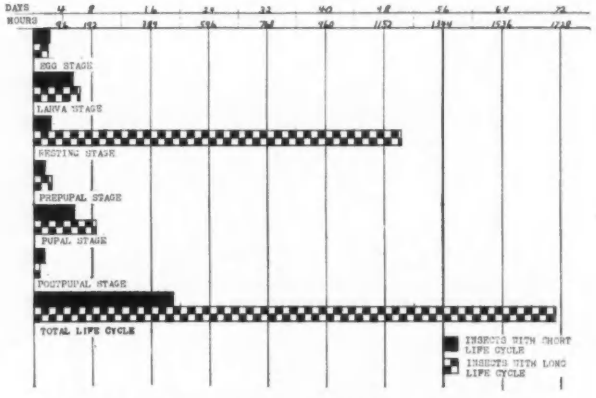

FIG. 1. Showing the variations in the life stages of the two types of male *Aenoplex carpocapsae* Cush.

When the cocoon of the codling moth larva is broken open, the parasite's cocoon, exposed to the light, quickly turns through the colors of white, yellow, and brown to black. About a day and a half is required for the completion of this change. As the pupa is extremely sensitive to light, this serves as a protection.

Whether the silk itself oxidizes in the light and turns black or the insect secretes an oxidizing substance could not be ascertained. Several cocoons containing insects were placed in a dark container, and, although the insects emerged, the cocoons remained white. Several others from which the

insects had been removed were placed in this container and some of them, after a week, were exposed to light. They colored rapidly and became black. The others were left in the container for five months and when exposed to light became brown within seventeen days. All cocoons placed in test tubes for emergence of the adults turned black.

Larvae from eggs laid at approximately the same time and held under the same conditions of light, heat, and humidity, go into resting states of two decidedly different lengths of time. The smaller larvae rest for from one to seven days, while the largest rest 37⅓ to 63½ days.

Following the resting period is a brief prepupal state in which the meconium is passed and the structures of the pupa become apparent before the exuvia is shed. For the short-lived insects the prepupal period lasts from 28 to 32 hours, while for the long-lived insects it is prolonged to 52 hours.

Finally the exuvia recedes from the beautiful white pupa which gradually colors to a jet black, white, and orange as it ages. The pupae average 6 millimeters in length and 1.5 millimeters in width. As mentioned above, they are very negative to light and are protected by the coloration of the cocoon. Although there was a difference in the sizes of the larvae, long and short lived, there was practically no variation in the sizes of the pupae. Regardless of this lack of variation the pupal period of the short-lived insects is from four to seven and one-fourth days, while the longer lived ones remain as pupae for from four and one-third to eleven days.

The adult male emerges and becomes fully dry within the cocoon, cutting its way out after approximately 24 hours, although it may remain for as short a period as four hours or for as long as 50 hours.

Of the insects observed, 13 per cent had long life cycles, 47 per cent the short life cycle, while a 40 per cent mortality was sustained. As will be noticed, during the various stages the 13 per cent predominated with a longer endurance, especially in the resting stage. This variation of life cycle within a species when the rearing was done under controlled conditions is not accountable for by any external factors, but may be an inherent factor which tends to produce males over a long period, insuring the presence of males at the time of the females.

NEW SPECIES OF APHIDS FROM COLORADO.

C. P. Gillette and Miriam A. Palmer,
Colorado Agricultural Experiment Station.

Epameibaphis atricornis, n. sp.

(Plate I, Fig. 1.)

Alate vivipara.

Color: Head and thorax dark brown to black; abdomen medium brown, when cleared showing dusky lateral areas and broken bands on abdominal segments 1 to 5, solid bands on segments 6, 7 and 8; antennae, except base of III, cornicles, genital plate and legs black, excepting anterior femora, which are dusky to pale on anterior side; cauda dusky. Veins of wings slightly smoky.

Measurements: Body to base of cauda, 1.4 mm.; width across eyes, .34 mm.; hind tibiae, .80 mm.; hind tarsi, .13 mm.; antennae, 1.45 mm.; III, .30 mm.; IV, .27 mm.; V, .24 mm.; VI, .11 + .43 mm.; cornicles, .33 mm.; cauda, .11 mm. for hard portion, .13 mm. for entire length; rostrum acute, tip beyond hairs needle-like, .07 mm. long, IV + V, .17 mm. long, attaining between 2nd and 3rd coxae.

Structural characters: Vertex nearly flat with slight median protuberance bearing the ocellus. Frontal tubercles absent. Secondary sensoria circular, with narrow rims and slightly convex, arranged in a single row along nearly entire length of joint, 4 on III, 0 on IV and V. Hairs on vertex blunt, hardly capitate, .03 mm. long; on antennae pointed, at angle of 45 degrees and .02 to .03 mm. long on I, II and III, as long as diameter of III rather sparse; on outerside of hind tibiae pointed and .04 to .05 mm. long, slightly longer than diameter of tibia, at angle of 45 degrees; on cauda pointed and curved, .07 mm. long; on body blunt, hardly capitate and .02 mm. long on sides of abdomen. Cornicles cylindrical, smooth and with knob-like tips, nearly twice as wide as hind tibiae, with clear area at base as though articulated to abdomen. Cauda tapering to rounded tip and with broader base, appearing slightly spoon-shaped, bearing three lateral pairs of hairs and a dorsal pair. Lateral tubercles not evident. Ocular tubercles rudimentary. Fore wings with mediae twice-branched; hind wings with both media and cubitus. Gonopophyses three.

Described from holotype taken on *Artemisia longifolia*, at Chimney Rock near state line in Larimer County, September 12, 1932.

Apterous summer vivipara.

Color: Medium brown, frosted; cleared specimens showing dusky on head, lateral areas on abdominal segments 3, 4 and 5, two rows of dorsolateral spots and solid bands on segments 7 and 8 and genital

plate, antennae black except joints II and III; legs black except anterior femora which are dusky to pale; cornicles black; cauda dusky.

Measurements: Body to base of cauda, 1.30 to 1.40 by .80 mm.; hind tibiae, .78 to .80 mm.; hind tarsi, .13 mm.; antennae, 1.2 to 1.45 mm.; III, .20 to .24 mm.; IV, .20 to .24 mm.; V, .19 to .24 mm.; VI, .10 to .14 + .37 to .50 mm.; cornicles, .33 to .36 mm.; cauda, .11 to .13 mm. hard portion, .14 to .16 mm. for entire length; rostrum as in alate vivipara and attaining abdomen.

Structural characters: Vertex nearly flat. Frontal tubercles lacking. Secondary sensoria absent on antennae. Hairs on vertex blunt or slightly fan-shaped at tip, .06 to .07 mm. long; on antennal I, II and III blunt, at angle of 45 degrees and .02 to .03 mm. long and sparse; on hind tibiae, spine-like, at 30 degrees and .04 to .05 mm. long, longer than diameter of tibia, rather numerous; on cauda pointed and curved, .07 mm. long; on dorsum of body same as vertex, .04 to .06 mm. long and fairly numerous. Cornicles and cauda as in alate vivipara.

Described from numerous morphotypes taken along with holotype.

Apterous ovipara.

Color: Same as apterous vivipara anteriorly to cornicles, posteriorly shining black; cleared specimens showing dusky on head, two longitudinal rows of dots and bands on abdominal segments 6, 7 and 8 and on entire genital plate; appendages as in apterous summer vivipara.

Measurements: Body to base of cauda, 1.40 to 1.60 mm. by .70 to .80 mm.; hind tibiae, .75 to .85 mm.; hind tarsi, .13 mm.; antennae, 1.45 to 1.50 mm.; III, .25 to .28 mm.; IV, .22 to .24 mm.; V, .22 to .24 mm.; VI, .13 + .43 to .51 mm.; cornicles, .33 to .40 mm.; cauda, .10 mm. hard portion, .15 mm. for entire length; rostrum as in summer viviparae.

Structural characters: Same as in apterous summer vivipara except hind tibiae which are swollen on approximately basal half to twice diameter of remaining part and bear between 20 and 30 rather large, flat sensoria and the cauda is broader and bears three lateral and three dorsolateral pairs and two single dorsal hairs.

Described from morphotypes taken October 21, 1932. Reared in insectary from same collection as holotype.

Egg.—When freshly laid, shining straw-yellow, greenish at one end; becoming brownish black in a few days.

Alate male.

Color: Same as alafe vivipara.

Measurements: Body to base of cauda, 1.30 mm.; hind tibiae, .85 mm.; hind tarsi, .13 mm.; antennae, 1.80 to 1.90 mm.; III, .35 to .40 mm.; IV, .30 to .36 mm.; V, .23 to .30 mm.; VI, .13 + .43 to .60 mm.; cornicles, .28 mm.; cauda, .06 mm. for hard portion, .09 mm. for entire length.

Structural characters: Same as alate vivipara except antennae which bear sensoria as follows: 26 to 32 on III, 24 on IV, 16 to 20 on V, and cauda which is acute and conical and bearing three pairs of hairs.

Described from allotypes taken in same collections as apterous oviparae described above.

Collections: One, besides the types mentioned above, apterous viviparae, taken June 26, on same host and at same locality. Host examined on these two dates only, insect quite abundant on leaves and in axils, quite agile.

Types in U. S. Nat. Mus., Cat. No. 49296; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is distinguished from *Epameibaphis frigidae* (Oestlund) (Geol. and Nat. Hist. Surv. Minn., 14th. Rept., p. 46, *Aphis*, 1886) by the darker color, brown instead of green, black appendages instead of pale and absence of secondary sensoria in apterae, and in alate viviparae 4 sensoria on III instead of 9 to 11.

Capitophorus brevinectarius, n. sp.

(Plate I, Fig. 2.)

Alate vivipara.

Color: Head and thorax brown, abdomen medium green with slightly dusky dorsal dashes and appearing frosted, due to funnel-shaped hairs; femora pale to brown; antennae, cornicles and tibiae blackish; cauda slightly dusky. Veins rather heavy and brown with slight border.

Measurements: Body to base of cauda, 1.55 mm. (1.55 to 1.80 mm.); head across eyes, .42 mm. (.42 to .45 mm.); hind tibiae, 1.25 mm. (1.20 to 1.30 mm.); hind tarsi, .15 mm.; antennae, 2.75 mm. (2.75 to 3 mm.); III, .61 mm. (.59 to .65 mm.); IV, .50 mm. (.43 to .53 mm.); V, .47 mm. (.50 to .53 mm.); VI, .14 mm. (.14 to .16 mm.) + .90 mm. (.80 to 1.00 mm.); cornicles, .09 mm. (.08 to .10 mm.) width same as hind tibiae; cauda, .25 mm. hard portion, .30 mm. for entire length; rostrum in ventral aspect with IV + V, .14 mm. long, very slender and tapering, tip beyond hairs needle-like, .06 mm. long, attaining 2nd coxae.

Structural characters: Vertex nearly flat with slightly protruding base for ocellus. Frontal tubercles distinctly developed. Secondary sensoria round, flat, arranged in irregular row along nearly entire length of joint III, 12 on one side and 14 on the other antenna (9 to 12), 0 on IV, 0 on V. Hairs on vertex with slender shaft and funnel-shaped at tip, .03 to .04 mm. long, on antennae blunt, drooping, .01 mm. long, sparse; on tibiae pointed, .02 mm. long, rather sparse, .6 as long as diameter of tibiae; on cauda, pointed, curved, .06 to .07 mm. long; on body funnel-shaped without stalk, .02 mm. long and numerous.

Cornicles cylindrical or slightly tapering, without distinct flange, imbricated. Cauda elongate and cylindrical or with slight neck and rather acutely rounded at tip, bearing two pairs of lateral hairs and two single dorsal ones. Lateral tubercles absent. Wing venation typical.

Described from holotype and 41 paratypes taken on leaves and twigs of *Artemisia longifolia* at Chimney Rock, June 26, 1932; found in large colonies; quite agile when disturbed.

Apterous summer vivipara.

Color: Medium green without markings; appearing frosted due to funnel-shaped hairs; femora pale to brown; antennae, tibiae and cornicles dusky, becoming black distally; cauda pale.

Measurements: Body to base of cauda, 1.95 to 2.20 mm.; other measurements same as alate vivipara.

Structural characters: Vertex convex. Frontal tubercles distinctly exceeding vertex. Secondary sensoria round and flat, 2 to 3 on basal .3 of III, 0 on IV and V. Other characters as in alate vivipara.

Described from four morphotypes taken in same colony with alate vivipara type.

No specimens taken besides the type collection of 45 specimens from a heavily infested small plant.

Types in U. S. Nat. Mus., Cat. No. 49294; paratypes in collection of Colo. Agr. Exp. Sta.

Capitophorus heterohirsutus, n. sp.

(Plate I, Fig. 3.)

Apterous summer vivipara.

Color: Pale green and appearing frosted due to numerous funnel-shaped hairs; all appendages pale brownish to dusky.

Measurements: Body to base of cauda, 1.50 by .77 mm.; across eyes, .35 mm.; hind tibiae, .58 mm.; hind tarsi, .12 mm.; antennae, 1.27 mm.; III, .29 mm.; IV, .19 mm.; V, .20 mm.; VI, .11 + .35 mm.; cornicles, .17 mm.; cauda, .12 mm. for hard portion, .15 mm. for entire length; rostrum acute in ventral aspect, IV + V, .14 mm.; portion beyond hairs, .06 mm., slender and needle-like, resembling distinct 5th joint, barely attaining 3rd coxae.

Structural characters: Vertex slightly convex. Frontal tubercles very slightly developed, barely exceeding vertex. Secondary sensoria circular, small, a single one located near base on III, 0 on IV or V. Hairs on vertex and dorsum of body varying from flattened funnel-shaped, without stalk, .015 to .02 mm. to cylindrical, .03 to .04 mm., with occasional pointed one, .07 to .10 mm.; on venter pointed; on antennae pointed, .02 to .03 mm., as long as diameter of III, at 60 to 80 degrees; on hind tibiae pointed, .02 to .04 mm. long, about as long as diameter of tibia, at 60 to 80 degrees, moderately numerous; on cauda pointed and curved, .05 mm. long. Cornicles cylindrical, slightly curved outwards, with

slight flange, imbrications elongated transversely. Cauda conical with slight neck, bearing two pairs of lateral hairs and a single dorsal one. Lateral tubercles not evident. Ocular tubercles rudimentary. Terminal pads on tibiae not evident.

Described from holotype taken on twigs and leaves of *Artemisia tridentata* on Sheep Creek in northern Larimer County, September 17, 1932, in crowded colony.

Apterous ovipara.

Color: Same as apterous summer vivipara.

Measurements and structural characters: Same as apterous summer viviparae except hind tibiae which are slightly swollen on basal .3 to .4 and bearing scattered small sensoria. Hairs in first instar young are all pointed and simple.

Described from numerous morphotypes taken with apterous summer vivipara described above.

Apterous male.

Color: Brown, frosted; appendages brownish.

Measurements: Body to base of cauda, 1 mm.; across eyes, .35 mm.; hind tibiae, .57 mm.; hind tarsi, .12 mm.; antennae, 1.20 to 1.40 mm.; III, .30 mm.; IV, .19 to .25 mm.; V, .19 to .22 mm.; VI, .11 + .27 to .33 mm.; cornicles, .06 to .12 mm.; cauda, .08 mm. for hard portion, .10 mm. for entire length; rostrum acute, IV + V, .11 mm. long; portion beyond hairs, .04 mm. long, needle-like.

Structural characters: Same as apterous vivipara except antennae bearing small sensoria rather thickly scattered over III, IV and V.

Described from allotypes taken with apterous summer vivipara described above.

No specimens taken except the type collection of about 100 specimens of sexuales and the single apterous summer vivipara.

Types in the U. S. Nat. Mus., Cat. No. 49297; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is peculiar on account of the variation in form of hairs and the short cornicles.

Capitophorus longinectarius, n. sp.

(Plate I, Fig. 4.)

Apterous summer vivipara.

Color: Entire dorsum pea-green, appearing frosted due to funnel-shaped hairs; all appendages pale to brownish.

Measurements: Body to base of cauda, 2.40 mm. (2.30 to 2.45 mm.); head across eyes, .60 mm.; hind tibiae, 1.77 mm. (1.15 to 1.77 mm.);

hind tarsi, .15 mm.; antennae, 4.55 mm. (3 to 4.90 mm.); III, .86 mm. (.70 to .90 mm.); IV, 1.00 mm. (.50 to 1.00 mm.); V, .77 mm. (.48 to .85 mm.); VI, .25 mm. (.18 to .25 mm.) + 1.40 mm. (.70 to 1.45 mm.); cornicles, 1.05 mm. (.70 to 1.05 mm.); cauda, .26 mm. for hard portion, .30 mm. for entire length; rostrum acute, IV + V, .15 mm. long, portion beyond hairs needle-like, .06 mm. long, surpassing 2nd coxae, resembling distinct 5th joint.

Structural characters: Vertex very slightly convex. Frontal tubercles well developed, greatly surpassing vertex. Secondary sensoria, round, small 1 (1 to 2) near base of III, 0 on IV or V. Hairs on vertex funnel-shaped with slender stalk, .04 mm. long, arising from tubercle; tubercle, .015 mm.; on antennal I, funnel-shaped to finger-like, sessile on tubercle, .02 mm. long, about 12 on dorsal side; on II slightly smaller; on III merely blunt, hardly .01 mm. long, very drooping and inconspicuous, rather numerous; on hind tibiae blunt to pointed, .02 mm. long, very drooping, numerous, .03 to .05 mm. apart; on cauda pointed, curved, .08 mm. long; on body funnel-shaped, with short stalk to sessile on tubercle, .015 to .025 mm. long, very numerous. Cornicles slightly clavate, curved, imbricated, with narrow flange. Cauda elongate, cylindrical, with blunt tip and bearing two pairs of lateral hairs and one on dorsum. Tibiae without terminal pad. Lateral and ocular tubercles apparently absent.

Described from holotype and 19 paratypes taken on leaves of *Artemisia longifolia* at Chimney Rock, June 26, 1932.

Types in U. S. Nat. Mus., Cat. No. 49298; paratypes in collection of Colo. Agr. Exp. Sta.

Capitophorus pullus, n. sp.

(Plate I, Fig. 5.)

Alate vivipara.

Color: Dorsum of head and thorax dark brown to blackish, abdomen medium brown due chiefly to body contents (cleared specimens show only slight brownish tint and slight traces of dorsal dashes); cauda and antennae dusky; legs dusky to black except most of 1st femora, which are pale brownish; cornicles black. Veins of fore wing heavy.

Measurements: Body to base of cauda, 2 mm.; head across eyes, .45 mm.; hind tibiae, 1.18 mm. (1.05 to 1.18 mm.); hind tarsi, .16 mm.; antennae, 2.05 mm. (1.95 to 2.05 mm.); III, .49 mm. (.44 to .49 mm.); IV, .37 mm. (.34 to .37 mm.); V, .34 mm. (.30 to .35 mm.); VI, .14 + .60 mm.; cornicles, .37 mm. (.33 to .42 mm.); cauda, .15 mm. for hard portion, .20 mm. for entire length; rostrum acute, tip needle-like; joint IV + V, .17 mm. long, tip, .06 mm. long, resembling distinct 5th joint, attaining barely to 2nd coxae.

Structural characters: Vertex convex. Frontal tubercles well developed, slightly exceeding vertex. Central ocellus ventrally placed. Secondary sensoria circular, nearly flat, arranged in single row along entire length of III, 9 (6 to 9) in number, 0 on IV or V; primary sensorium on base of VI with only two accessory sensoria. Hairs on vertex blunt,

.03 mm. long, on occiput funnel-shaped without stalk; on all antennal joints blunt to pointed, .01 to .02 mm. long, shorter than width at middle of III; on outside of middle of hind tibiae pointed, .02 to .04 mm. long, at angle of 45 degrees, barely as long as width of tibia; on cauda pointed, slightly curved, .06 mm. long; on body funnel-shaped without stalk, .02 to .04 mm. long. Cornicles slightly clavate, with distinct flange and rather coarsely imbricated. Cauda elongate, conical with acute tip, and bearing two to three pairs of lateral hairs and a single dorsal one near tip. Ocular tubercles rudimentary. Fore wings with mediae twice branched. Hind wings with both media and cubitus and with three hamuli. Terminal pad on tibiae very inconspicuous.

Described from holotype and 7 paratypes taken on leaves of *Artemisia longifolia*, June 26, 1932, at Chimney Rock.

Apterous summer vivipara.

Color: Entire dorsum medium brown; appendages as in alate vivipara.

Measurements: Body to base of cauda, 1.7 to 2.2 mm.; head across eyes, .47 mm.; hind tibiae, .85 to 1.05 mm.; hind tarsi, .15 to .17 mm.; antennae, 1.3 to 1.7 mm.; III, .23 to .46 mm.; IV, .18 to .33 mm.; V, .18 to .28 mm.; VI, .10 to .13 + .33 to .52 mm.; cornicles, .30 to .50 mm.; cauda, .18 mm. for hard portion, .23 mm. for entire length; rostrum surpassing 2nd coxae.

Structural characters: Secondary sensoria, 1 to 2 on basal portion, 0 on IV or V. Hairs on vertex cylindrical to slightly funnel-shaped with long stalk, .04 to .05 mm. long; on antennal I and II blunt and .03 mm. long, on III, .01 to .02 mm.; on outerside of middle of hind tibiae pointed, .04 to .05 mm. long, about as long as diameter of tibiae; on body (on side of abdominal segments 4 and 5) fan-shaped without stalk to funnel-shaped or occasionally nearly cylindrical, .01 to .04 mm. long. Other characters as in alate vivipara.

Described from 22 morphotypes taken with alate viviparae described above.

No collections taken besides the one above mentioned.

Types in U. S. Nat. Mus., Cat. No. 49293; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is peculiar on account of the brown color and the two kinds of hairs on head.

Kakimia[1] **cerei,** n. sp.

(Plate I, Fig. 6.)

Alate vivipara.

Color: Head and thorax brown; abdomen pale yellow or greenish without markings; cauda and cornicles pale to slightly dusky; antennae

[1]*Kakimia* Hottes and Frison (Ill. Nat. Hist. Surv. Bul. 19, p. 344, 1931) was erected as a subgenus under *Myzus*, but in the opinion of the writers it is of generic value.

dusky with I and II and base of III lighter; legs dusky except bases of femora; tips of tibiae and entire tarsi black.

Measurements: Body to base of cauda, 1.80 mm.; across eyes, .42 mm.; hind tibiae, 1.50 mm. (1.25 to 1.70 mm.); hind tarsi, .09 mm.; antennae, 2.20 mm.; III, .65 mm. (.55 to .80 mm); IV, .34 mm. (.33 to .43 mm.); V, .35 to .40 mm.; VI, .10 mm. (.10 to .12 mm.) + .70 mm. (.60 to .70 mm.); cornicles, .40 mm. (.35 to .45 mm.); cauda, .15 mm. (.15 to .20 mm.) for hard portion, .20 mm. (.20 to .25 mm.) for entire length; rostrum obtuse, IV + V, .17 mm. (.17 to .19 mm.), attaining 3rd coxae.

Structural characters: Vertex convex. Frontal tubercles but slightly exceeding vertex. Secondary sensoria circular, somewhat tuberculate, .50 mm. (.30 to .60 mm.), scattered along entire length of III, none on IV and V. Hairs blunt to slightly capitate; on vertex, antennae, outerside of hind tibiae and side of abdomen, .03 to .04 mm. long; nearly erect. Cornicles cylindrical, with flange and faintly imbricated. Cauda cylindrical with slight neck, bearing two pairs of lateral hairs and a single dorsal one at tip. Lateral tubercles not noticeable.

Described from holotype and four paratypes taken on curled leaves of *Ribes cereum*, July 15, 1929, in Estes Park (alt. 8,000), by the senior author, also five paratypes taken on *Ribes* sp., June 16, 1918, in Poudre Canon by L. C. Bragg.

Apterous summer vivipara.

Color: Entire dorsum pale yellowish green; cauda pale to slightly dusky; cornicles and antennae pale basally to dusky distally; legs pale with tips of tibiae and entire tarsi black.

Measurements: Body to base of cauda, 1.7 to 2 mm.; hind tibiae, 1.20 to 1.60 mm.; hind tarsi, .08 to .09 mm.; antennae, 1.8 to 2.23 mm.; III, .50 to .65 mm.; IV, .30 to .40 mm.; V, .26 to .33 mm.; VI, .10 to .12 + .43 to .58 mm.; cornicles, .40 to .50 mm.; cauda, .20 mm. for hard portion, .25 mm. for entire length.

Structural characters: Same as alate vivipara except secondary sensoria on III, 7 to 17 on basal half and cauda slightly broader.

Described from about 20 morphotypes taken with holotype and paratypes of alate vivipara and numerous others taken on *Ribes* sp., July 23, 1921, and August 15, 1921, near Estes Park; 8 on June 5, 1912, near Boulder; 40 taken on *Ribes cereum* at Cherokee Park, September 23, 1932; 8 taken June 30, 1915, near Fort Collins.

Apterous ovipara.

Color: Entire dorsum pale yellowish green, appendages pale except distal ends of tibiae and antennae and entire tarsi which are blackish.

Measurements: Body to base of cauda, 1.75 mm.; hind tibiae, .80 mm.; hind tarsi, .08 mm.; antennae, 1.25 mm.; III, .28 to .32 mm.; IV, .18 to .22 mm.; V, .18 mm.; VI, .09 + .35 to .37 mm.; cornicles,

.23 mm.; cauda, .15 mm. for hard portion, .18 mm. for entire length; rostrum with IV + V, .17 mm.; attaining 3rd coxae.

Structural characters: Same as in apterous summer vivipara except secondary sensoria 0 to 3 on III; cauda stouter, and hind tibiae slightly swollen on basal half and rather thickly covered with scattered sensoria.

Described from about 12 morphotypes taken in curled leaves of *Ribes cereum*, September 23, 1932, at Cherokee Park.

Alate male.

Color: Same as alate vivipara except entire antennae and legs, beyond bases of femora, black.

Measurements: Body to base of cauda, 1.75 mm.; hind tibia, antennae and rostrum as in alate vivipara except III .48 to .55 mm.; cornicles, .18 mm.; cauda, .08 mm. for hard portion, .11 mm. for entire length.

Structural characters: Same as alate vivipara except secondary sensoria about 34 on III, 6 on IV, 8 on V; cauda conical.

Described from allotypes taken with morphotypic apterous summer viviparae and oviparae in curled leaves of *Ribes cereum*, September 23, 1932, at Cherokee Park.

Collections: On underside of curled leaves of *Ribes cereum* and *Ribes* sp., near Estes Park, Cherokee Park, Boulder, Fort Collins, Stove Prairie Hill[2] and Poudre Canon.

Apterous summer vivipara—Ten collections, June 30 to September 23. *Alate viviparae*—Two collections, June 16 to July 15. *Apterous oviparae*—One collection, September 23, 1932. *Alate males*—Two collections, August 15 to September 23.

Types in U. S. Nat. Mus., Cat. No. 49295; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is closely allied to *Myzus alpinus* G. and P. (Ann. Ent. Soc. Amer., 21: 18, 1928), but differs in absence of sensoria on antennal IV and V in alate viviparae, hairs slightly longer and more erect, cornicles in apterous viviparae almost as long as unguis instead of less than half, in alatae longer than half instead of about one-third and unguis shorter than III instead of longer, also dorsum always without dusky markings.

Amphorophora brevitarsis, n. sp.

(Plate II, Fig. 1.)

Fundatrix.

Color: Dorsum of head pale greenish buff, rest of body pale yellowish green or pale apple-green; antennae pale brownish with tips of joints

[2]Near Bellevue, alt. 7,000.

III, IV and V and entire VI black; legs pale to brownish except tips of tibiae and entire tarsi which are black; cornicles pale at base, becoming brownish distally with tips blackish; cauda pale.

Measurements: Body to base of cauda, 2 to 2.75 mm.; hind tibiae, 1.65 to 1.90 mm.; hind tarsi, .12 mm.; antennae, 2.65 to 3 mm.; III, .70 to .80 mm.; IV, .45 to .56 mm.; V, .45 to .55 mm.; VI, .16 to .19 + .48 to .56 mm.; cornicles, .80 to .95 mm.; cauda, .20 mm. for hard portion, .28 mm. for entire length; rostrum IV + V, .14 mm., obtuse, slightly surpassing 2nd coxae.

Structural characters: Secondary sensoria circular, 1 to 2 on basal portion of III; other characters as in summer aptera.

Described from 16 morphotypes taken on leaves of *Clematis ligusticifolia*, at Fort Collins, April 28, 1930, and one in Poudre Canon, alt. 7,000, April 26, 1918.

Apterous summer vivipara.

Color: Entire dorsum pale yellowish green to pale yellowish; all appendages pale to brownish, except tips of antennal III, IV and V, entire VI, tips of tibiae and cornicles and entire tarsi, which are dusky to black.

Measurements: Body to base of cauda, 2 to 3 mm.; across eyes, .47 to .50 mm.; hind tibiae, 2 to 2.3 mm.; hind tarsi, .12 mm.; antennae, 4 to 4.10 mm.; III, .77 to 1.06 mm.; IV, .50 to .78 mm.; V, .50 to .66 mm.; VI, .16 to .18 + 1.00 to 1.26 mm.; cornicles, .80 to 1.10 mm.; cauda, .23 mm. for hard portion, .26 mm. for entire length; rostrum as in alate vivipara.

Structural characters: Secondary sensoria, 1 to 12 on III, 0 on IV or V. All other characters as in alate vivipara.

Described from three morphotypes taken with holotype and eight taken with paratypes of alate vivipara, also 12 taken July 1, 1927, same host and locality.

Alate vivipara.

Color: Head and thorax yellowish brown; abdomen pale greenish yellow; legs pale to brownish with tips of tibiae and entire tarsi blackish to black; antennae dusky; cornicles pale to brownish, dusky distally; cauda pale; wings hyaline.

Measurements: Body to base of cauda, 2.30 mm. (2.3 to 3 mm.); head across eyes, .50 mm.; hind tarsi, .12 mm.; hind tibiae, 2.30 mm. (2 to 2.30 mm.); antennae, 4.30 mm. (4.3 to 5 mm.); III, .95 mm. (.75 to .95 mm.); IV, .84 mm. (.70 to .84 mm.); V, .75 mm. (.65 to .75 mm.); VI, .19 mm. (.16 to .19 mm.) + 1.36 mm. (1.10 to 1.36 mm.); cornicles 1 mm. (1 to 1.05 mm.); cauda, .25 mm. for hard portion, .30 mm. for entire length; rostrum obtuse, IV + V, .15 mm. long, attaining 2nd coxae.

Structural characters: Vertex slightly convex. Frontal tubercles greatly exceeding vertex. Secondary sensoria circular, nearly flat, 19 (19 to 20) in single row along almost entire length of III, 0 on IV or V.

Hairs blunt; on vertex, .03 mm. (.02 to .03 mm.) long; on antennae, .01 mm. at 30 degrees; on outer side of hind tibiae, .02 to .03 mm. long, shorter than diameter of tibiae; on cauda, .09 mm. long and pointed; on body (sides of abdomen), .01 to .02 mm. and sparse. Cornicles slightly clavate on distal .3, but constricted on reticulated area (.12 mm.) next to flange, expanded at base, narrowest portion slightly wider than hind tibiae. Cauda conical, rather acute, bearing 3 or 4 pairs of lateral hairs. Lateral tubercles inconspicuous, shallow. Ocular tubercles normal. Fore wings with mediae twice-forked; hind wings with both media and cubitus.

Described from holotype taken on leaves of *Clematis ligusticifolia* at Fort Collins, September 16, 1927, and two paratypes taken July 18, 1929, and September 25, 1932, respectively, same host and locality.

Apterous ovipara.

Color: Dorsum pale greenish yellow with greenish median line; appendages as in apterous summer vivipara.

Measurements: Same as apterous summer vivipara.

Structural characters: Same as apterous summer vivipara excepting hind tibiae, which are slightly swollen on basal half and bear numerous small slightly convex sensoria and cauda which is slightly shorter and broader.

Described from four morphotypes taken on same host and locality as holotype, September 25, 1932.

Egg.

Color: Pale green when first laid, turning black later.

Measurements: .07 by .035 mm. Bluntly rounded at ends.

Alate male.

Color: Same as alate vivipara except slight dusky markings on lateral areas and dorsal dashes on abdomen anterior to cornicles.

Measurements: Body to base of cauda, 1.60 mm.; head across eyes, .44 mm.; hind tibiae, and antennae as in alate vivipara; cornicles, .70 mm.; cauda, .10 mm. for hard portion, .14 mm. for entire length.

Structural characters: Secondary sensoria rather large, 40 in a single row along entire length of III, 0 on IV, 14 to 16 small ones in a single row on V. Other characters as in alate vivipara.

Described from six allotypes taken on same host and locality as holotype, October 7 to 10, 1927.

Collections: On leaves of *Clematis ligusticifolia* as follows: *Fundatrices*—Two collections, April 26 and 28. *Apterous summer viviparae*—Six collections, July 1 to September 25. *Alate viviparae*—Three collections, July 18 and September 16

and 25. *Apterous oviparae*—Four collections, September 25 to October 23. *Alate males*—Two collections, September 28 to October 10.

Eleven collections in all; rather common but inconspicuous on account of protective coloration, concealed position under leaves and usually solitary habit.

Types in collection of U. S. Nat. Mus., Cat. No. 49292; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species seems to resemble *Macrosiphum clematidis* Takahashi (1927, "Aphididae of Formosa," Pt. 5, Dept. of Agr. Govt. Res. Inst., Rept. No. 22, p. 2), but differs in sensoria of alate viviparae not numbering 45 and cornicle being slightly swollen. From *Amphorophora nervata* (Gillette) (Can. Ent., 40: 63, *Rhopalosiphum*, 1908) it differs slightly in presence of sensoria on antennae of apterae, amount of reticulation on cornicles and length of rostrum.

Macrosiphum atripes, n. sp.

(Plate II, Fig. 2.)

Alate vivipara.

Color: Head and thorax dark; abdomen dark reddish brown to blackish red; cauda pale, cornicles and antennae black throughout; legs black except bases of femora which are paler; rostrum black distally; wings hyaline, veins slender.

Measurements: Body to base of cauda, 1.85 mm. (1.85 to 3 mm.); across eyes, .56 mm.; hind tibiae, 1.60 mm. (1.60 to 1.80 mm.); hind tarsi, .13 mm. (.13 to .14 mm.); antennae, 2.65 mm. (2.54 to 3 mm.); III, .78 mm. (.60 to .90 mm.); IV, .48 mm. (.48 to .73 mm.); V, .44 mm. (.38 to .53 mm.); VI, .13 mm. (.11 to .14 mm.) + .68 mm. (.68 to .80 mm.); cornicles, .60 mm. (.55 to .80 mm.) long, .07 mm. wide at middle; cauda, .38 mm. for hard portion, .42 mm. for entire length; rostrum obtuse with IV + V, .15 mm., attaining 3rd coxae or abdomen.

Structural characters: Frontal tubercles well developed. Secondary sensoria subcircular, convex, with rims, 56 (34 to 56) scattered over entire joint III, 0 on IV or V. Hairs blunt to pointed, on vertex, .03 to .04 mm. long; on antennae, .03 mm. long and nearly erect; on outer side of hind tibiae, .03 to .04 mm. long, about as long as diameter of tibia, pointed, at 45 degrees; on side of abdomen, .03 mm. long. Antennal III and IV smooth. Cornicles cylindrical, with flanges, reticulated on distal .25 mm. (.25 to .30 mm.), remainder slightly imbricated. Cauda slender, cylindrical with slight neck and acute tip, bearing 5 lateral and 3 dorsolateral hairs on each side and a single dorsal one at tip.

Described from holotype and 17 paratypes taken on leaves and stems of *Aster* sp., near Masonville, September 2, 1932.

Apterous summer vivipara.

Color: Entire dorsum dark reddish brown to blackish red, with dusky hair bases; appendages as in alate vivipara.

Measurements: Same as alate vivipara except rostrum which attains 1st or 2nd abdominal segment, hairs which are sometimes .01 mm. longer and cornicles, at middle, .01 mm. wider.

Structural characters: Same as in alate vivipara except that secondary sensoria on III number 24 to 44.

Described from numerous morphotypes taken with holotype and paratypes.

Collections were taken on leaves and stems of *Aster* sp. and *Solidago missouriensis* near Masonville (Spring Canon) and Bellvue (Stove Prairie Hill), September 2, 1932, alate and apterous viviparae, only two collections taken but very abundant on *Aster* in that locality.

Types in collection of U. S. Nat. Mus., Cat. No. 49291; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is separated from *Mac. lanceolatum* Patch (Me. Exp. Sta. Bul. 282, p. 215, 1919) in sensoria on antennal third joint in alate viviparae, being more than 30 and in apterae more than 20, cauda longer than "about equal to IV," reticulation of cornicle being longer than "2/7 of length of cornicles."

Macrosiphum longirostris, n. sp.

(Plate II, Fig. 3.)

Alate vivipara.

Color: Head and thorax brown; abdomen light green; cornicles blackish, lighter at base; antennae pale on I, II and base of III, remainder black; legs black except bases of femora; cauda pale.

Measurements: Body to base of cauda, 2.20 mm. (2 to 3 mm.); hind tibiae, 1.75 mm. (1.6 to 1.75 mm.); antennae, 2.60 mm. (2 to 3 mm); III, .72 mm. (.60 to .72 mm.); IV, .55 mm. (.53 to .60 mm.); V, .48 mm. (.40 to .48 mm.); VI, .12 + .60 mm. (.56 to .60 mm.); cornicles, .97 mm. (.70 to 1 mm.); cauda, .25 mm. (.25 to .30 mm.) for hard portion, .32 mm. (.32 to .35 mm.) for entire length; rostrum with IV + V slender, obtuse, nearly acute, .24 mm. long, attaining 3rd coxae or abdomen.

Structural characters: Frontal tubercles well developed. Secondary sensoria circular, strongly convex but hardly tuberculate, scattered over entire joint, about 40 on III, none on IV or V. Hairs on vertex and antennal I to VI, slightly capitate or blunt, .04 mm. long; on outer side of hind tibiae blunt, .04 mm. long at angle of 45 degrees and moderately numerous; on sides of body slightly capitate and .04 mm. long. Cornicles cylindrical to tapering at base, more or less curved, width at middle

twice that of hind tibiae or antennal III, reticulated on distal .35 mm., with flange. Cauda conical with slight constriction and slender tip, bearing four pairs of lateral hairs and one or two dorsal hairs, about four of the terminal ones blunt to slightly capitate. Wing veins slender.

Described from holotype and five paratypes taken September 2 to 5, 1917, and three paratypes taken July 28 and 29, 1925, at Fort Collins, on heads and under side of leaves of *Cirsium filipendulum*.

Apterous summer vivipara.

Color: Head, thorax and abdomen light green without dark markings; antennae beyond base of III, tips of tibiae, tarsi and distal .3 of cornicles dusky; cauda pale to slightly dusky.

Measurements: Body to base of cauda, 2.10 to 2.80 mm.; hind tibiae, 1.55 to 1.75 mm.; hind tarsi, .13 mm.; antennae, 2.40 to 2.60 mm.; III, .60 to .75 mm.; IV, .55 to .60 mm.; V, .40 to .50 mm.; VI, .12 + .50 to .65 mm.; cornicles, .75 to 1.10 mm.; cauda, .35 to .45 mm. for hard portion, .40 to .50 mm. for entire length; rostrum as in alate vivipara, but attaining 1st abdominal segment.

Structural characters: Same as in alate vivipara except sensoria on antennal III, 14 to 24 scattered over basal .6.

Described from two morphotypes taken with holotype and 14 morphotypes taken with paratypes of alate viviparae.

No collections taken besides the ones mentioned above.

Types in U. S. Nat. Mus., Cat. No. 49289; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species appears to be very close to *Macrosiphum erigeronensis* Thomas (Ill. St. Lab. Nat. Hist., Bul. 2, p. 7, 1877) but differs mainly in rostral IV + V being distinctly longer than base of antennal VI; cornicle diameter at middle being distinctly greater than .06 mm.; cauda being also stouter and hairs being slightly longer.

Macrosiphum mertensiae, n. sp.

(Plate II, Fig. 4.)

Alate vivipara.

Color: Not observed during life. Mounted specimens appear pale throughout body and cauda; legs pale except distal ends of tibiae and entire tarsi which are dusky; cornicles pale with about distal .3 slightly dusky; antennae pale with distal portion of IV and entire V and VI dusky.

Measurements: Body to base of cauda, 2.5 mm. (2 to 3 mm.); head across eyes, .43 mm.; hind tibiae, 2.30 mm. (2 to 2.40 mm.); hind tarsi, .16 mm.; antennae, 3.60 mm.; III, .90 mm. (.80 to .90 mm.); IV, .60 mm.

(.60 to .65 mm.); V, .62 mm. (.55 to .68 mm.); VI, .20 mm. (.17 to .20 mm.) 1.00 mm. (.92 to 1.00 mm.); cornicles, .80 mm. (.70 to .80 mm.); cauda, .30 mm. for hard portion, .35 mm. for entire length; rostrum obtuse, joint IV + V, .14 mm. long, attaining 2nd coxae.

Structural characters: Frontal tubercles well developed. Antennal III finely imbricated. Secondary sensoria circular with narrow rims, rather large, about .3 to .5 the diameter of joint, arranged in irregular double row along almost entire length of III, about 20 in number; 0 on IV and V. Hairs blunt to slightly capitate; on vertex about .03 mm. long; on antennae, .02 to .03 mm. long, and moderately numerous; on outer side of hind tibiae, .04 to .05 mm. long; on cauda, .07 to .10 mm. long, pointed and slightly curved; on body, .03 mm. Cornicles cylindrical reticulated on distal .18 to .20 mm., imbricated on remainder, with flange. Cauda elongate conical to cylindrical, with slight neck, bearing four pairs of lateral and two dorsal hairs. Mediae of fore wings with 2nd fork about .3 the distance from margin of wing to first fork.

Described from holotype and two paratypes taken on *Mertensia* sp. at Colorado Springs, June 19, 1917, by L. C. Bragg.

Apterous summer vivipara.

Color: Not observed during life; in mounted specimens all parts colorless except tips of antennae, cornicles and tibiae and entire tarsi, which are slightly dusky.

Measurements: Same as alate vivipara except head across eyes .50 to .53 mm.; cornicles, .75 to .95 mm. and cauda, .35 to .40 mm. for hard portion, .40 to .45 mm. for entire length.

Structural characters: Same as alate vivipara except sensoria 8 to 10 on basal .3 of antennal III.

Described from 13 morphotypes taken with holotype described above.

No collection taken besides the one already mentioned, apparently rare.

Types in collection of U. S. Nat. Mus., Cat. No. 49290; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species differs from *Adactynus niwanista* Hottes on *Mertensia sibirica* (Pr. Biol. Soc., Wash., 46: 16, 1933) in the following characters: cornicles distinctly longer than antennal IV instead of less than .6 of IV and twice length of cauda instead of not exceeding 1.5 times cauda; sensoria on III in alate viviparae rather large, more than 18, not small, and in single row; sensoria on III in apterae 7 to 10 instead of 1 to 2 and base of antennal VI .18 to .20 mm., not .24 to .31 mm.

Macrosiphum tenuitarsis, n. sp.
(Plate II, Fig. 5.)

Alate vivipara.

Color: Dorsum of head and thorax brown, abdomen apple-green; cauda pale; cornicles black, paler at base; antennae with I, II and base of III pale, remainder dusky to blackish. Legs dusky to blackish except basal .3 of femora.

Measurements: Body to base of cauda, 2.5 mm. (2.5 to 3 mm.); hind tibiae, 2.30 mm.; hind tarsi, .20 mm. (.20 to .22 mm.), slender, .02 to .025 mm. wide, antennae, 4 mm.; III, .95 mm. (.85 to 1.06 mm.); IV, .75 mm. (.73 to .80 mm.); V, .72 mm. (.72 to .80 mm.); VI, .19 mm. (.17 to .20 mm.) + 1.08 mm. (.95 to 1.08 mm.); cornicles, .70 mm. (.65 to .85 mm.); cauda, .47 mm. (.40 to .47 mm.) for hard portion, .55 mm. (.50 to .56 mm.) for entire length; rostrum obtuse, joint IV + V, .14 mm. long, attaining 2nd coxae.

Structural characters: Frontal tubercles well developed. Secondary sensoria circular, slightly convex, but not tuberculate, scattered along almost entire length of III, 27 (27 to 37) in number, 0 on IV or V. Hairs on vertex blunt, .025 to .03 mm. long; on antennal III and legs, pointed, about .04 mm. long, at 45 degrees and rather numerous, hardly as long as diameter of joint bearing them; on cauda pointed, nearly straight, .10 mm. long; on body blunt, .04 mm. long. Cornicles cylindrical or slightly tapering, .06 mm. wide at middle, reticulated coarsely for .18 mm., finely and transversely to .25 or .27 mm., remainder imbricated, flange indistinct. Cauda parallel-sided or slightly constricted and ending with slender acute tip, bearing four or five pairs of hairs. Wings hyaline, venation normal. Hamuli, 4.

Described from holotype and one paratype taken August 2, 1912, and two paratypes taken August 4, 1912, on *Aster laevis*, at Boulder, and six paratypes taken on *Aster* sp., July 15, 1915, at Estes Park; all by L. C. Bragg.

Apterous summer vivipara.

Color: Same as alate vivipara.

Measurements: Body to base of cauda, 2.5 to 3 mm.; hind tibiae, 2.35 to 2.75 mm.; hind tarsi, .20 mm.; antennae, 4 to 4.3 mm.; III, .92 to 1 mm.; IV, .65 to .80 mm.; V, .60 to .80 mm.; VI, .20 to .22 + .95 to 1.18 mm.; cornicles, .92 to .80 mm.; cauda, .55 mm. hard portion, .67 mm. entire length; rostrum with IV + V, .14 mm. long and surpassing 2nd coxae.

Structural characters: Same as in alate vivipara except sensoria on III, hardly extending beyond basal half, 16 to 19 in number.

Described from 15 morphotypes taken with holotype and paratypes.

Apterous ovipara.

Color: Same as apterous vivipara.

Measurements: Body to base of cauda, 2 to 2.50 mm.; hind tibiae, 1.75 to 1.95 mm.; hind tarsi, .18 to .20 mm. by .02 mm. wide; antennae, 2.90 to 3.2 mm.; III, .80 to .95 mm.; IV, .50 to .55 mm.; V, .53 to .63 mm.; VI, .20 to .22 + .80 to .90 mm.; cornicles, .50 to .60 mm.; cauda, .40 mm. for hard portion, .50 mm. for entire length; rostrum as in apterous vivipara.

Structural characters: Same as in apterous summer vivipara except hind tibiae which are noticeably swollen on basal .5 to .6 and bearing numerous flat sensoria.

Described from 15 morphotypes taken on *Aster* sp., October 4 and 5, in foothills near Fort Collins, by L. C. Bragg.

Alate male.

Color: Head and thorax dark brown; abdomen olive-brown; cauda dusky; other appendages blackish, with cornicles slightly lighter at bases.

Measurements: Body to base of cauda, 2.20 mm.; hind tibiae, 1.80 mm.; hind tarsi, .20 mm.; antennae, 3 mm.; III, .75 to .80 mm.; IV, .53 to .60 mm.; V, .50 to .58 mm.; VI, .17 to .19 + .60 (?) to .85 mm.; cornicles, .30 to .45 mm.; cauda, .12 mm. for hard portion, .17 mm. for entire length; rostrum with IV + V, .13 to .17 mm. long, attaining 2nd coxae.

Structural characters: Same as alate vivipara except 48 to 50 sensoria on III, 9 to 16 on IV and 10 to 18 on V; reticulation on cornicle extending .10 to .15 mm. from tip.

Described from allotypes taken with oviparae.

No collections besides the ones above-mentioned.

Types in U. S. Nat. Mus., Cat. No. 49288; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is peculiar on account of the long slender tarsi and base of VI. It differs from *Mac. subviride* MacDougall (Pan. Pac. Ent., 2, (4): 170, 1926) in not leaving the *Aster* for an alternate winter host, in having longer cauda and tarsi and shorter unguis. It differs from *Mac. lanceolatum* Patch (Me. Exp. Sta. Bul. 282, p. 215, 1919) in having fewer caudal hairs, longer tarsi, shorter rostral IV + V, shorter tibial hairs, and in color not being red. From *Mac. anomalae* H. & F. (Ill. Nat. Hist. Surv. Bul. 19, p. 298, 1931) it differs in tarsi not being .12 mm. long, sensoria on antennal III of apterous vivipara not numbering as many as 28 to 41, and in having longer antennae, cornicles and body. From *Mac. erigeronensis* Thos. (Ill. St. Lab. Nat. Hist. Bul. 2, p. 7, 1877) it differs in the longer tarsi, unguis not being shorter than III or cornicle.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. *Epameibaphis atricornis*, n. sp.
Fig. 2. *Capitophorus brevinectarius*, n. sp.
Fig. 3. *Capitophorus heterohirsutus*, n. sp.
Fig. 4. *Capitophorus longinectarius*, n. sp.
Fig. 5. *Capitophorus pullus*, n. sp.
Fig. 6. *Kakimia cerei*, n. sp.

Plate II.

Fig. 1. *Amphorophora brevitarsis*, n. sp.
Fig. 2. *Macrosiphum atripes*, n. sp.
Fig. 3. *Macrosiphum longirostris*, n. sp.
Fig. 4. *Macrosiphum mertensiae*, n. sp.
Fig. 5. *Macrosiphum tenuitarsis*, n. sp.

ABBREVIATIONS.

Ca.—cauda.
Co.—cornicle.
G.—gonopophyses.
Viv.—vivipara.
R.—rostrum.
Ti.—hind tibia.
Ta.—hind tarsus.
♀—ovipara.

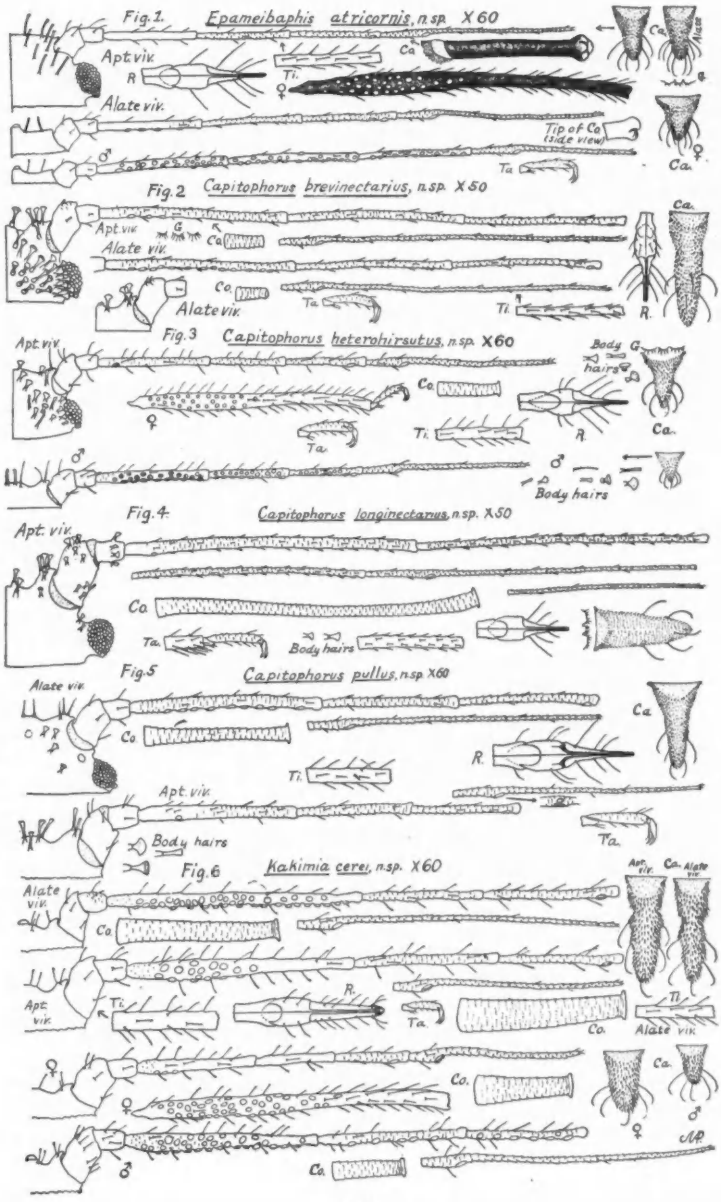
Fig. 1. Epameibaphis atricornis, n.sp. X60
Apt. viv.
R
Ti.
Ca
Alate viv.
Tip of Ca (side view)
Ta
Fig. 2 Capitophorus brevinectarius, n.sp. X50
Apt. viv.
Alate viv.
Ca
Ti.
R.
Fig. 3 Capitophorus heterohirsutus, n.sp. X60
Apt. viv.
Body hairs
Ca
Ti.
R
Ta.
Fig. 4. Capitophorus longinectarius, n.sp. X50
Apt. viv.
Ca
Ta.
Body hairs
Fig. 5 Capitophorus pullus, n.sp. X60
Alate viv.
Ca
R.
Ti.
Apt. viv.
Ta.
Body hairs
Fig. 6 Kakimia cerei, n.sp. X60
Alate viv.
Apt. viv.
Ca.
Co.
Ti.
R.
Ta.
MP

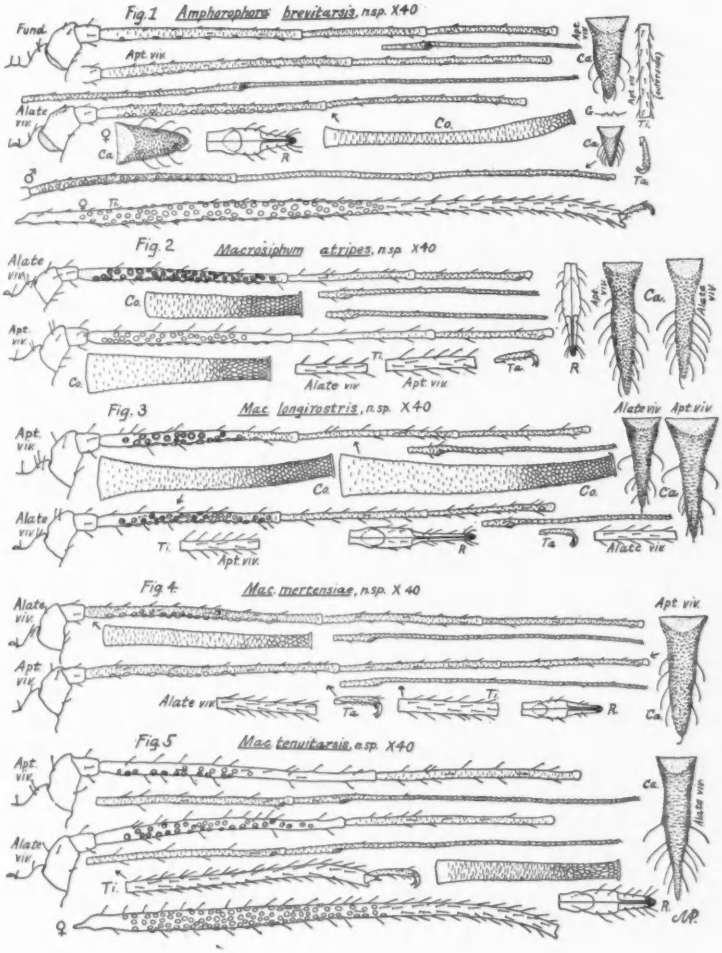
Fig. 1 Amphorophora brevitarsis, n.sp. X40
Fund.
Apt. viv.
Alate viv.
Ca.
R
Ti.
Ta.
Fig. 2 Macrosiphum atripes, n.sp. X40
Alate viv.
Apt. viv.
Ca.
Ti.
Ta.
R
Fig. 3 Mac. longirostris, n.sp. X40
Alate viv
Apt viv
Fig. 4 Mac. mertensiae, n.sp. X 40
Fig. 5 Mac. tenuitarsis, n.sp. X40

INHERITANCE OF SONG IN HYBRIDS OF TWO SUBSPECIES OF NEMOBIUS FASCIATUS (ORTHOPTERA).[1]

B. B. Fulton,
North Carolina State College.

In an earlier publication the writer (1) discussed the relationship of three races of *Nemobius fasciatus*, namely: *N. f. socius* Scudder, *N. f. fasciatus* (De Geer) and *N. f. tinnulus* Fulton. The three subspecies have slight morphological and color differences when the average condition of each in respect to certain characters is considered. Some individuals of each race are intermediate in respect to these characters so that it is often impossible to classify a specimen that is not one of a series collected at the same place. *N. f. fasciatus* is the connecting link between the other two races.

PHYSIOLOGICAL CHARACTERS.

In regard to certain physiological characters the three races are more distinct. The song of the male is their most obvious attribute. In this respect *socius* stands apart. Its notes are produced by a rapid vibration of the tegmina as they are brought together. This vibration only becomes apparent when the movement is retarded by low temperature. The notes have a slower frequency and a more buzzing, less musical quality than the other two races. The notes of *fasciatus* and *tinnulus* are single-stroke chirps and their songs differ only in frequency of notes. With *fasciatus* the movement is so rapid at normal summer temperatures as to give the effect of continuous sound but with a noticeable tremolo. When heard singing during cool weather it becomes apparent that each movement of the tegmina produces a single sharp chirp. With *tinnulus* the intermittent character of the song is evident at all times, for the frequency of notes is only about half that of *fasciatus*.

The seasonal history of *socius* in North Carolina differs from that of the other races. It begins to mature in June and has more than one generation annually. No more than two

[1]Published with the approval of the Director of Research as paper No. 68 of the journal series.

generations were obtained in the breeding jars, but both nymphs and adults may be found out of doors in late fall and it seems probable that breeding is continued as long as the weather will permit. *Fasciatus* and *tinnulus* never mature until late summer and nymphs are not found in late fall. In the northern states the time of appearance of adults indicates that no race has more than one generation annually.

In choice of habitat the three races also show marked differences. *Socius* is a grassland race occurring in greatest numbers in moist meadows and marsh borders. In the northern states it is confined to low ground, but in the south it is more widely distributed. *Tinnulus* is a woodland race living in the less densely shaded types of developmental or subclimax woodland or around the borders of climax forest. In respect to habitat also *fasciatus* is intermediate between the other two races. It is associated with grass, but may live in open woodland or under trees where there is enough light to permit a good growth of grass. In the eastern Piedmont region of North Carolina it occurs sparingly in partly shaded places along streams where blue grass and other mesic grasses will grow. In the mountain regions and northern states it is the most common race and occurs in both open and partly shaded places, but is scarce or absent on poorly drained ground where *socius* lives.

In any region there is a marked tendency for each race to occupy its own habitat to the exclusion of the other races. In certain transitional areas like the borders of woodland there is some intermingling of two races. The question arises as to whether they interbreed in such places. Observations in the field have not revealed any individuals that are intermediate in regard to their song, which is always distinctly one type or another.

Socius-tinnulus MATING.

The crossing experiments with *socius* and *tinnulus*, previously reported, show that these two races, which are at opposite extremes in respect to all characters, will frequently mate when confined together. Virgin females were used and the spermathecae examined for evidence of mating. Of seven pairs only two showed empty spermathecae. Of four cases where a male was confined with females of both races only one showed

evidence of mating with the different race, but all mated with their own kind. No offspring were obtained from any of the crosses.

As a result of these studies the writer expressed the belief that the three subspecies are physiologically distinct and that any individual belongs to one of the three, but that morphologically they have not diverged far enough to permit positive classification of all individuals. Further breeding experiments were carried on to test this theory.

CROSSING EXPERIMENTS WITH THREE SUBSPECIES.

During 1930 all of the three races were used in crossing experiments. The race *fasciatus* was obtained from the mountains of North Carolina. Up to that time no *fasciatus* had been found in the Piedmont. All pairs were kept in glass jars with about an inch of fine sandy soil in the bottom. They were fed and watered until the female died.

The following crosses were made:

Females	Males		
	socius	*fasciatus*	*tinnulus*
socius	5 pairs	4 pairs	4 pairs
fasciatus	4 pairs	3 pairs	3 pairs
tinnulus	4 pairs	5 pairs	3 pairs

As a check against possible parthenogenesis several females of each race were kept unmated. After the crickets died, all jars were kept over winter in an unheated insectary and a little water was occasionally added to the soil. During the following spring the soil in all jars was kept moist for a much longer time than would be necessary for fertile eggs to hatch. A large number of nymphs were obtained from all crickets paired with their own race except one pair of *fasciatus*. The female of this pair was found dead on September 29, whereas most of the crickets lived until late October or November. Seven of the eight *fasciatus-tinnulus* crosses gave numerous progeny. One *fasciatus* female paired with a *tinnulus* male gave no progeny. The male of this pair died before October 10 and on October 30 the female was found dead but not decayed. An examination

of the body revealed a few eggs in the ovaries and an empty spermatheca. No nymphs appeared in jars which had contained unmated females or any of the other crosses with one exception. One nymph was found in a jar which had contained a *fasciatus* female paired with a *socius* male. This nymph unfortunately died while still young. There is a possibility that it may have come from a *socius* egg on a small grass clump placed in the jar for food. Grass clumps used were always carefully washed to remove all soil before placing them in the jars, but it is possible that an egg may have been caught in the mass of roots. No race but *socius* was present where the grass was obtained. The later stages of *socius* nymphs can be identified by their markings from the other two races, so the possibility of such a source of error in the *fasciatus-tinnulus* crosses is eliminated.

Among the *socius* paired with their own race was a female from Raleigh with a male from the mountains of North Carolina, where the race is restricted to low ground as in the northern states. A question arises as to whether the wider distribution of *socius* east of the mountains is due to further racial splitting or to a better adaptation of the race to southern environment or to a lack of competition with *fasciatus*. The fertility of the above mentioned pair shows at least a close relationship between the crickets from the two areas.

In the previous year's experiments only two out of seven crosses of *tinnulus* and *socius* showed evidence that the adults had failed to mate. It seems improbable that the failure to obtain progeny in the 1930 crosses involving *socius* could be due entirely to lack of mating. In a desire to obtain as many eggs as possible no females were killed and when found dead they were usually decayed. One female *fasciatus*, which had been paired with a *socius* male for 20 days, was found dead but not decayed. The ovaries were packed with eggs and the spermatheca was empty.

The evidence of this series of experiments seems conclusive that the hybridization of *socius* with either of the other two races would be unlikely to occur in nature. The experiments also show that hybridization of *fasciatus* and *tinnulus* is possible. If the song type of either race were inherited as a dominant character it would be impossible to detect hybrids occurring in nature.

To determine this it was necessary to rear the nymphs to maturity. There was high mortality among them during the hot weather, but five males and several females of the hybrids and several controls of each race survived. The controls sang in the same manner as their male parents, but the song of the hybrids was intermediate between that of the two parent races in frequency of notes. This was apparent even during hot weather when it was impossible to make any close estimate of the chirping rate. Fortunately for the experiment there came a period of cool weather during which the chirping rates could be computed by counting every fourth note for a period of about 10 seconds. This gave a reasonably close estimate for rates up to about 7 per second, but was probably inaccurate for rates higher than that. The records of the hybrid songs are indicated in Fig. 1 by the numeral 1. *Tinnulus* song records are indicated by the letter T, and *fasciatus* by F. Those enclosed in a circle were taken by another method the following year.

In color the F1 hybrids appeared more like *tinnulus*, but the characters of the tegmina were not definitely of either race. Some of the hybrids developed long wings, a dimorphic character common in *fasciatus* but not yet found in *tinnulus*.

F2 GENERATION.

Five pairs of F1 hybrids were mated, one hybrid female was back-crossed with *tinnulus* and two with *fasciatus* males. The jars containing the eggs from these pairs were brought into the laboratory early in the winter in the hope that adults might be obtained during the cool spring weather. Nymphs appeared in January, but they developed slowly and adults were not obtained until June so that there was little prospect of observing the songs under cool weather conditions. In order to get some estimate of the frequency of notes a vibrating interrupter was used. This consists of a long steel spring held by a clamp. By shifting the position of the clamp a wide range of vibrations can be obtained. A needle is attached perpendicularly to one end of the spring. By setting the spring into vibration and allowing the needle point to rub lightly against a thin piece of paper a sound somewhat similar to the chirping of the crickets could be obtained. This was compared to the cricket song and when the sound made by the needle seemed to have the

same frequency as the cricket chirps, the position of the clamp on the spring was recorded. After records were taken at various temperatures the rates were established for all positions of the clamp by recording the vibrations on a kymograph sheet on which second intervals were also recorded. The chief source of error in the method would be in comparing the song with the vibrations of the spring and this would probably not be greater than one note per second. Records of the song of *tinnulus* at 80° F. by this method (T in a circle) are about one

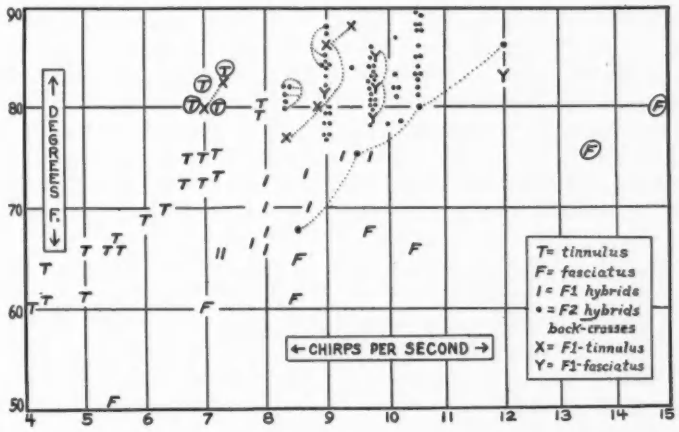

FIG. 1. Chirping rates of *Nemobius fasciatus fasciatus* (F) and *N. fasciatus tinnulus* (T) and their hybrids of the first (1) and second (dots) generation, and progeny of back-crosses of the first generation hybrids with *fasciatus* (Y) and *tinnulus* (X). Records connected by dotted lines are from the same individual.

note per second slower than the estimates made by counting every fourth note. Allowance must be made for inaccuracy in actual chirping rate for records above six notes per second, but the general relative position of the records at any one temperature is more certain. When several crickets are heard singing at one time their relative speeds are apparent even though the determination of the actual rates might be mere guess work.

The records obtained for the F2 generation are shown in Fig. 1 as dots. These were taken from 21 individuals most of which came from one pair of F1 parents. The songs of two

male offspring from F1 and *tinnulus* parents are designated by "X" and three from F1 and *fasciatus* parents by "Y." While these records were taken at higher temperatures than those of F1 songs it can be seen that most of the F2 generation records have an intermediate position also. There is slightly more variation in rate. Some of the F2 songs were consistently more rapid and others consistently slow. The records from a few such individuals are connected on the graph by dotted lines.

One of the offspring from the back-cross with *tinnulus* sang at the same rate as *tinnulus*, but the other was faster. Of the three male offspring from the *fasciatus* back-cross two were like the F2 hybrids and one was faster than the F2 but much slower than *fasciatus*. The two *fasciatus* records above 70° were from specimens collected near Raleigh, while the others, taken the year before, were from the mountain stock used in the experiments.

CONCLUSIONS.

If the intermediate chirping rate of the F1 generation were due to incomplete dominance of a single determiner, the F2 generation should show about one-fourth singing like *tinnulus* and another fourth like *fasciatus*. A few approximated the *tinnulus* song but none the *fasciatus* song. The results are more like what would be expected from the segregation of two or more determiners. The experiments show that F1 hybrids and the majority of the F2 generation would have an intermediate chirping rate which would reveal their presence in the male sex if they occurred in nature. The writer has listened to the songs of these crickets in a number of places where both races were intermingled, both in Iowa and North Carolina, and has never detected a song that seemed to be of intermediate quality. If hybrids occur in nature they must not be of common occurrence. All evidence so far leads one to conclude that the three races of *Nemobius fasciatus* are more distinct physiologically than morphologically, and that they seldom if ever interbreed under natural conditions.

DISCUSSION.

If these insects did not sing it is doubtful whether the existence of *tinnulus* as a subspecies would have been detected.

The typical russet color had been noted in woodland specimens but was considered a variation due to local environmental influence. The species had formerly been divided into two geographic races, *fasciatus* in the north and *socius* in the south. The writer makes no plea for the naming of purely physiological races having no morphological basis. *Nemobius fasciatus* was a border line case in which two races had already been named and the third seemed to have as well defined physical characters as the other two. Physiological races revealed by song differences are not uncommon among the Orthoptera. The races of *Oecanthus niveus* which are purely physiological have been studied by the writer (2). Other cases, which have been detected but not studied experimentally, are found in the genera, *Gryllus*, *Anaxipha*, *Cycloptilum* and *Amblycorypha*.

Since most insects do not sing, one is led to speculate on the number of undiscovered physiological races that may exist among insects, races differing in food habits, seasonal history, ecological distribution and in other characteristics that can be determined only by careful breeding work. The existence of such habit differences could bring about an isolation of races almost as complete as if they were separated by mountain barriers. Barriers are regarded as an important factor in the evolution of species. Whenever diversity of habits in a species reaches the point where adults of one group are separated by time or space from the other, then the practical effect of a barrier is produced.

From an economic standpoint the recognition of the existence of physiological races is sometimes important. For instance, no benefit would be derived from destroying the wild food plants of an insect pest if the species existed as two races, one feeding on the crop and the other on the wild plant. Examples of racial host selection may be found in the works of Thorpe (3) on *Hyponomeuta* and Lathrop and Nickels (4) on *Rhagoletis*. In studies on the resistance of wheat varieties to Hessian fly, Painter (5) has shown that there is evidence for the existence of genetically distinct strains of the fly differing in their ability to infest various wheat varieties. Some physiological characters within a species may have geographical limitations as shown by the work of Hough (6) on the relative resistance to arsenical poisoning by codling moth larvae from Colorado and Virginia, and by Compere and Smith (7) on the resistance of a

California scale insect to a parasite which breeds on the same species of scale in Japan.

REFERENCES.

(1) **Fulton, B. B.** A Study of the Genus Nemobius. Ann. Ent. Soc. Amer. **24**: 205–237, 1931.
(2) ———. Physiological Variation in the Snowy Tree-cricket. Ann. Ent. Soc. Amer. 18: 363–383, 1925.
(3) **Thorpe, W. H.** Biological Races in Hyponomeuta padella L. Jour. Linn. Soc. Zool. 36 (249): 621–634, 1929.
(4) **Lathrop, F. H.,** and **Nickels, C. B.** The Blueberry Maggot from an Ecological Viewpoint. Ann. Ent. Soc. Amer. **24**: 260–281, 1931.
(5) **Painter, R. H.** Biological Strains of Hessian Fly. Jour. Econ. Ent. **23**: 322–326, 1930.
(6) **Hough, W. S.** Relative Resistance to Arsenical Poisoning of two Codling Moth Strains. Jour. Econ. Ent. 21: 325–329, 1928.
(7) **Compere, H.** and **Smith, H. S.** Notes on the Life History of Two Oriental Chalcoid Parasites of Chrysomphalus. Univ. Calif. Publ. Ent. **4** (4): 63–73, 1927.

THE JUNGLE BEES AND WASPS OF BARRO COLORADO ISLAND (With Notes on Other Insects), by PHIL RAU. Pages 8 and 1–324, including an appendix of 9 pages by J. BEQUAERT. 106 photographic illustrations. 1933. Published by the Author, Kirkwood, Mo. $2.75.

The author needs no introduction as he has given us more knowledge of the details of the life of our social wasps than any other student. This volume records his observations made during a five weeks stay on Barro Colorado in 1928. The table of contents records, Chapter I, The Stingless Bees of Barro Colorado Island; II, The Polybia Wasps; III, The Behavior of Two Species of Polistes Wasps; IV, Other Paper-making Social Wasps; V, The Solitary Wasps; VI, Ecological and Behavior Notes on Spiders and Various Insects; VII, Miscellaneous; The Fallen Sand-box Tree, etc.; VIII, The Great Carpenter Bee; IX, Mind as a Forerunner of Evolution; Appendix.

This volume is well written field natural history by an authority in ecology and animal behavior, an unusual combination of abilities. It is interesting reading whether to one merely interested in the queer doings of insects or to one interested in the biological problems met with on every hand. Having spent his previous time on studies of the social wasps of temperate regions, Rau makes a special effort to discern the differences in habits between these and the habits of social wasps in a hot, humid, tropical rain-forest.

The final chapter gives his conclusions (after a life of work in the field of behavior) as to just how a new species of social insect may arise from the preceding population. He argues that with changed conditions some venturesome individual has to decide with changed behavior to accept the new food or new manner of living which will permit survival. That the first move of a previous species towards a new species-form is psychic, this new effort is crystallized into instinct later and eventually is followed by morphological distinctions. It is a chapter that attempts to combine the three current trends of thought on the origin of species.

Concerning the volume Dr. W. M. Wheeler writes, "It is in my opinion one of the most outstanding recent contributions to natural history containing as it does a large amount of new and very valuable material on Neotropical bees and wasps."

The book is well bound and well printed. It is the type of volume that should be included in the "outside" reading of every student of entomology.—C. H. K.

A NEW NAME FOR MUTILLA DIMIDIATA LEPELETIER, WITH A REDESCRIPTION OF THE TYPE SPECIMEN.[1]

CLARENCE E. MICKEL,
University of Minnesota.

Timulla (Trogaspidia) orientalis n. n.

1845. *Mutilla dimidiata* Lep., Hist. Nat. Ins., Hymen., 3: 628, male (nec Latreille, 1792).
1910. *Mutilla dimidiata* Zavattari, Ann. Mus. Zool. Univ. Napoli, 3 (no. 9): 9, male.

The name *dimidiata* proposed by Lepeletier in the genus *Mutilla* is preoccupied by *Mutilla dimidiata* Latreille proposed in 1792. *Dimidiata* Latreille is apparently still unrecognized, although Andre, in Vol. 8: 441 of "Species des Hyménoptères d'Europe and d'Algerie, 1903, suggests the possibility of it being the same as *Myrmosa melanocephala* Fabr. In any event, the name *dimidiata* cannot be used for Lepeletier's species since it had already been used by Latreille. I therefore propose the name *orientalis* to replace *dimidiata* Lepeletier, as indicated above.

There has been a great deal of confusion in the literature concerning the identity of Lepeletier's species. This is due to the fact that the diagnostic characters, particularly the form of the clypeus, and the form of the terminal abdominal segments, were not formerly recognized. Zavattari called attention to this confusion in 1910 and pointed out that *Mutilla dimidiata* Sichel and Radoskowski, 1869, *M. dimidiata* Magretti, 1892, and *M. dimidiata* Bingham, 1897, were not the same as Lepeletier's species, and having seen Lepeletier's specimens he gave a redescription of the species. I have not been able to examine the specimens upon which the identifications of Sichel and Radoskowski, Magretti and Bingham were based, but think that Zavattari was correct in concluding these authors did not have Lepeletier's *dimidiata*, and that probably the specimens in these three cases represent at least two, and possibly three distinct species.

[1]Published with the approval of the Director as Paper No. 1129 of the Journal Series of the University of Minnesota Agricultural Experiment Station.

Zavattari in 1913 (Arch. f. Naturg., Vol. 79 (part 3): 28) recognizing that if *dimidiata* Sichel and Radoskowski, Magretti, and Bingham were not the same as *dimidiata* Lepeletier, a new name was in order for the three former, suggested *amartana* as a new name and also listed thirteen specimens which he referred to that name. Since Zavattari chose no type locality for *amartana* and did label his specimens as that species, I have chosen in the following paper (The Mutillidae of Formosa) to designate one of his specimens as lectotype of *amartana* and to select Formosa as the type locality. Since *amartana* is peculiar to Formosa and none of the specimens of *dimidiata* Sichel and Radoskowski, Magretti, and Bingham came from Formosa, it is certain that none of their material is the same as *amartana* Zavattari. *Dimidiata* Sichel and Radoskowski, 1869, Magretti, 1892, and Bingham, 1897, are therefore still without a name. Since their material is not available to me for examination and the possibility exists that three different species may be involved, I prefer to leave them without a name until some definite knowledge can be had of them.

Orientalis belongs to a section of the subgenus *Trogaspidia* in which the scutellum is evenly and slightly convex, not gibbosely elevated as usual, and in which the hypopygium is simple, without elevated ridges. None of the groups related to *Trogaspidia* and proposed as genera by Bischoff (1920) are suitable for receiving such a combination of characters. I have not been able to correlate any corresponding differences in the females known from the oriental region and therefore prefer to regard the group of species possessing these characters as a section of *Trogaspidia*.

Thanks to the kindness of Dr. A. Arcangeli, Director of the Museo Zoologia et Anatomia comparata della R. Universita, of Turin, Italy, I have been able to examine the material on which Lepeletier based his description of *dimidiata*. There are two specimens labeled "Mutilla dimidiata Lep., typus Coll. Serville, Indo-Orientale." They form a part of the Spinola Collection, which is under Dr. Arcangeli's care. The two specimens are conspecific and I have labeled one of them as lectotype. The additional descriptive notes which I made at the time I examined the lectotype are as follows:

DESCRIPTION.

Head, thorax, first abdominal segment and legs, black; remainder of abdomen entirely ferruginous; mandibles robust, heavy, broad and tridentate at the apex, deeply emarginate and toothed beneath near the base; clypeus flat, depressed conspicuously below the dorsal margin of the mandibles, its posterior margin elevated medially into a conspicuous, acute tubercle or tooth between the antennal tubercles; scape obscurely bicarinate beneath; first segment of flagellum about half the length of the second; front and vertex with moderate, shallow, close punctures; front anterior to the ocelli clothed with thick, pale golden pubescence; vertex and genae with sparse, recumbent, pale pubescence and sparse, erect, dark hairs; vertex rounded, not elevated and furrowed longitudinally; ocelli small, the distance between the lateral ocelli and the inner margins of the eyes equal to about three times the greatest diameter of a lateral ocellus; pronotum with moderate, dense punctures, clothed with black pubescence; mesonotum with moderately large, dense punctures, clothed with black pubescence; scutellum convex, not elevated medially, with moderate, dense punctures and sparse, black pubescence; dorsum of propodeum with a narrow, elongate, enclosed space, the dorsum and posterior face otherwise moderately reticulate and rounded into one another; mesopleurae bluntly elevated dorsally and convexly elevated ventrally, a conspicuously foveolate furrow between the two elevations; sides of propodeum shallowly reticulate; tegulae small, not extending more than one-fourth their length beyond the posterior margin of mesonotum, glabrous, impunctate, except the anterior and inner margins punctate and black pubescent; first abdominal segment black, except the posterior margin of the tergite ferruginous; first tergite clothed with sparse, erect, golden ferruginous pubescence, the apical fringe also golden ferruginous; segments 2–7 ferruginous, clothed above and beneath with golden ferruginous pubescence; second tergite with moderate, distinct punctures, close at the base and sides, sparse medially; last tergite evenly convex throughout, with moderately large, close, somewhat confluent punctures, except the apical two-thirds with a median, impunctate line; hypopygium depressed along the median, longitudinal line, not ridged or dentate laterally; first sternite with a median, longitudinal carina on the anterior two-thirds; lateral margins of mesosternum with a distinct, blunt tubercle in front of the middle coxae; legs entirely black, sparsely clothed with pale pubescence; wings fuscous; cell R + 1st R_1 equal in length to cell 2nd R_1 + R_2; distance between the base of the stigmatic cell and origin of vein M equal to the length of the former; cell R_5 receiving vein M_{3+4} at two-thirds the distance from base to apex; cell R_4 present, but less distinct than R_5, receiving vein M_2 about two-thirds the distance from base to apex; cell 2nd R_1 + R_2 rounded apically, acute on the costal margin.

Dimidiata auct. has been recorded not only from India but also from Ceylon, Timor and Luzon. I have no knowledge

as to whether *orientalis* is found in Ceylon. I have examined all the type material described from the Pacific Islands, including Timor, many other specimens determined by various authors as *dimidiata* Lep., and several thousand specimens from the Philippine Islands, many of which were from Luzon, but have failed to find any specimens resembling *orientalis*. A subspecies of *orientalis* is known from Formosa and is treated in the following paper on the Mutillid fauna of that island.

THE PROBLEMS OF INSECT STUDY, by PAUL KNIGHT. 118 pages (lithoprinted) with numerous unnumbered illustrations. Published by the Author, College Park, Md. $3.00.

The nature of this volume is best stated by the author himself. "This is a book on entomology for people who encounter insects in newspaper columns, gardens, kitchens, clothes presses, or at the seaside; people who would like to learn something about them, but do not want to become professional entomologists to do so. It might be called a consumer's entomology rather than an entomologist's guide book. . . . There is nothing established or settled in the form or material of this book, and therefore it has been prepared in a form that can be quickly revised." The table of contents is as follows: Chapter I, The Struggle to Control the Universe; II, Insects, Economics and Man; III, Time, Space and Insects; IV, Hexapods, Octopods, and Myriapods; V, Evolution and Taxonomy; VI, The Insect Problem; VII, Entomological Progress, and Appendix; 1, Entomological Literature; 2, Some of the More Important Insects not Native to the United States; 3, Brief List of Some Insects Native to the United States.

The volume contains much very interesting information of a semipopular kind not usually found in texts on entomology. Among many standard entomological references one finds in one bibliography, "The Decameron," "Oriental Rugs," "Shellac," Defoe, "A Journal of the Plague Year," etc., etc. As is stated by the author in his introduction, record was kept for eight years of the questions asked and items which interested beginning students most in entomology and this volume is an attempt to write a book covering such interests. The volume is curious and informative to any entomologist raised on "Comstock" or other standard text. The author's approach is unique but the volume needs much rewriting and an index or a more detailed table of contents.—C. H. K.

THE MUTILLIDAE OF FORMOSA.[1]

CLARENCE E. MICKEL,
University of Minnesota.

Our knowledge of the Mutillid fauna of Formosa is based almost without exception on material collected by H. Sauter, and on a study of that material made by E. Zavattari (1913). The latter recognized thirty-one species, twenty-seven of which were referred to the genus *Mutilla*. The four remaining species were assigned to *Myrmilla*, *Promecilla* and *Odontomutilla*. Nine species were recorded from Formosa which had previously been described from other localities in the Oriental region. The writer found it necessary to consider the Formosa fauna in connection with other studies of Mutillidae and has examined not only the Sauter material, but also the type material of those species described by other authors and recorded by Zavattari as occurring in Formosa. In all such cases the type material proved to be different and distinct from the specimens on which the Formosa records were based. The result was that a number of the Formosa species remained undescribed. It was also found that the generic assignments of the Formosa species were in need of revision since the species assigned to the genus *Mutilla* by Zavattari represented several genera, none of which were *Mutilla*. The latter genus is apparently not represented in Formosa. In examining the material studied by Zavattari it was found that holotypes had not been designated and it seemed desirable to designate lectotypes. In all cases the specimen selected by me as lectotype has been labeled with a red label bearing the term "lectotype."

In general it was found that the Mutillidae of Formosa are distinct from species and subspecies found in other Pacific Islands. No subspecies is known to be common to both Formosa and the Philippine Islands, although related subspecies occur in the two regions. The relationship between Formosa and continental forms in China is much closer. Certain specimens from the region of Hongkong and Canton appear to be indistinguishable, even on subspecific grounds, from certain forms in Formosa. The results of the writer's study with respect to the generic arrangement of the species, descriptions of new species, and designation of lectotypes, follow.

[1]Published with the approval of the Director as Paper No. 1130 of the Journal Series of the University of Minnesota Agricultural Experiment Station.

The author is greatly indebted to Dr. Carl Zimmer, Director, and Dr. H. Bischoff, Zoologisches Museum der Universität, Berlin, Germany; to Dr. Walther Horn, Director, Deutsches Entomologisches Institut, Berlin-Dahlem, Germany; and to Dr. A. Arcangeli, Director, Museo Zoologia et Anatomia comparata della R. Universita, Turin, Italy, for the privilege of studying the Sauter material treated by Zavattari in his 1913 paper. Acknowledgment is also due the authorities at the British Museum of Natural History, London; Museum National d'Histoire Naturelle, Paris; Hungarian National Museum, Budapest; and Museo Civico di Storia Naturale, Genoa, Italy, for the privilege of examining other type material.

KEY TO GENERA.

MALES.

1. Tegulae small, scale-like, convex, smooth and shining, the hind margin not reflexed; mandibles beneath unarmed..... 2
   Tegulae distinctly larger, the hind margin distinctly reflexed, or if not then the latter coarsely sculptured; mandibles beneath armed or not.... 3
2. Tergites 3–7 without a median, longitudinal carina. (Page 383)....**Myrmilla**
   Tergites 3–7 with a distinct, median, longitudinal carina. (Page 383), **Squamulotilla**
3. First abdominal segment broad and transverse; posterolateral angles of scutellum produced, thus more or less dentate. (Page 388)..**Odontomutilla**
   First abdominal segment of rather slender form, sessile but never strongly, transversely developed; posterolateral angles of scutellum not produced... 4
4. Vertex not at all elevated posteriorly, not flattened, rounded throughout, the posterior margin not truncate, punctate throughout without any trace of striae; distance between origin of vein M on vein R and the base of the stigmatic cell scarcely greater than the length of the latter. (Page 388).....**Timulla (Trogaspidia)**
   Vertex elevated posteriorly, more or less flattened, truncate posteriorly at the middle, distinctly striatopunctate throughout; distance between origin of vein M on vein R and the base of the stigmatic cell equal to twice the length of the latter. (Page 416).....**Smicromyrme**

FEMALES.

1. Mesopleurae with a very prominent, vertical, lamelliform projection just above the middle coxae..... 2
   Mesopleurae without such a vertical, lamelliform projection..... 3
2. Head very large, usually broader than the thorax, quadrate, strongly developed behind the eyes. (Page 383).....**Myrmilla**
   Head smaller, not broader than the thorax, not quadrate, only moderately developed behind the eyes. (Page 383).....**Squamulotilla**
3. First abdominal segment strongly transverse, short, sharply truncate anteriorly, presenting a broad, anterior surface at right angles to the abdomen; thorax more or less hexagonal, the sides converging anteriorly and posteriorly. (Page 388).....**Odontomutilla**
   First abdominal segment sessile, but not strongly transverse, not sharply truncate anteriorly; thorax rectangular, the sides approximately parallel.. 4
4. Second abdominal tergite ornamented with a pair of pale pubescent spots. (Page 388).....**Timulla (Trogaspidia)**
   Second abdominal tergite either without spots, or with unpaired, pale pubescent spots, sometimes only one, sometimes three. (Page 416), **Smicromyrme**

Genus **Myrmilla** Wesmael.

Myrmilla hoozana Zavattari.

1913. *Myrmilla hoozana* Zavattari, Arch. f. Naturg., 79 (part 3): 22, male.

Lectotype.— Male, Hoozan, IV, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

There is still some question as to whether this species should be referred to the genus *Myrmilla*. At the time I examined the type material it was not possible to determine whether it properly belongs to this genus or whether a new genus should be established to receive it. Apparently it cannot be correctly referred to any other established genus.

Genus **Squamulotilla** Bischoff.

This genus was erected by Bischoff (1920) to receive several African male Mutillidae among which *denticollis* Bischoff was designated as type. These males are related to the genus *Myrmilla* and one of their distinguishing characteristics pointed out by Bischoff was the relative length of the second and third flagellar segments, the second being distinctly shorter than the third. While a general generic description was given by Bischoff, no other characters were pointed out as fundamentally characteristic. The female sex has heretofore remained unknown. In my study of the Formosa Mutillidae, as well as the Mutillid fauna of the Philippine Islands, Oceanic Islands, and China, certain males have been encountered which are unquestionably congeneric with the genotype of this genus, *Squamulotilla denticollis* Bischoff. All are characterized in having a median, longitudinal carina on abdominal tergites three to seven. I consider this character of more fundamental generic importance than the relative length of the first two flagellar segments. There are a number of Mutillid genera in which the relative length of these two flagellar segments varies within the genus. I know of only one other genus, *Ephuta* Say, the males of which possess a median, longitudinal carina on the terminal abdominal tergites. These longitudinal carinae are present without exception in all the males of *Ephuta* which are known. I have not had an opportunity to examine the African males assigned to this genus which are said not to possess the carinae on the terminal abdominal tergites, but

my opinion at present is that they should be excluded from *Squamulotilla*. I have been able to associate the two sexes in my study of the Mutillid fauna of the above mentioned regions. The females, like the males, are related to the females of *Myrmilla*. In both genera there is a prominent, vertical, lamelliform projection on the mesopleurae just above the middle coxae which is invariably present but which varies in the degree of its development. It appears to be more strongly developed in the females of *Squamulotilla* than in *Myrmilla*. The females of the two genera differ in the size and shape of the head as indicated in the above key.

Species referable to *Squamulotilla* as defined above are found in India, Malay Peninsula, China, Formosa, Philippine Islands and many of the Oceanic Islands, as well as in Africa.

KEY TO THE MALES OF SQUAMULOTILLA.

1. Entirely black; second sternite with a median longitudinal carina terminating in a large, submarginal, blunt tubercle. (Page 384)...**tumidula**
   Thorax entirely ferruginous; second sternite with a median, elongate elevation on the apical half. (Page 386).....**formosana**

KEY TO THE FEMALES OF SQUAMULOTILLA.

1. Junction of the posterior and dorsal surfaces of thorax slightly serrate, but without a transverse row of long, vertical teeth..... 2
   Junction of the posterior and dorsal surfaces of thorax with a transverse row of long, vertical teeth..... 3
2. Median spot on first tergite and apical band of second tergite white, the color integumental and pubescent; tergites 3–5 entirely black pubescent. (Page 386).....**erdae**
   Median spot on first tergite and apical band of second tergite white, the maculations formed only by silvery pubescence; tergite three also with an apical band of pale pubescence. (Page 386).....**carinulifera**
3. Median spot on first tergite and apical band of second tergite white, the color integumental and pubescent; tergite three with an apical, transverse, obscure spot of pale pubescence; tergites 4 and 5, black pubescent. (Page 386).....**trituberculata**
   Median spot on first tergite and apical band of second tergite white, the maculations formed only by pale pubescence; tergites 3–5, each with a median, apical, transverse spot of whitish pubescence. (Page 386)..**sauteri**

Squamulotilla tumidula n. sp.

Male.—Entirely black, clothed throughout with sparse, pale pubescence, except the front, mesonotum and last two abdominal tergites with blackish pubescence; mandibles not excised beneath; first segment of flagellum shorter than the second; second abdominal sternite with a median, longitudinal carina extending posteriorly from the anterior margin and terminating in a submarginal, prominent, blunt tubercle near the posterior margin; hypopygium with a transverse, prominent carina near the anterior margin; wings with two submarginal cells, cell R_4 entirely absent. Length, 9 mm.

Head entirely black, clothed with sparse, erect and recumbent, pale pubescence, except the front and anterior part of vertex with

sparse, blackish pubescence; mandibles piceous, slender, edentate at the tip and with a small tooth within near the apex, not at all excised beneath; median area of clypeus elevated, finely, closely punctate, and with sparse, pale pubescence; scape with a single, obscure carina beneath, finely, closely punctate throughout; first segment of flagellum distinctly shorter than the second when viewed from beneath; antennal scrobes carinate above; front, vertex and genae with small punctures, distinct and well-separated on the front, distinct and approximate on the vertex, close and somewhat confluent on the genae; ocelli small, the distance between the eye margins and the lateral ocelli about five times the greatest diameter of the latter; relative widths of head and thorax, including the tegulae, 3.0–3.1.

Thorax entirely black, clothed throughout with sparse, pale pubescence, except thick on the mesopleurae medially, and the mesonotum with sparse, blackish pubescence; pronotum and mesonotum with moderately small, close, more or less confluent punctures; parapsidal furrows absent; scutellum evenly convex throughout, with moderately small, dense, confluent punctures; dorsum of propodeum and posterior face distinctly reticulate throughout, the one rounded into the other, the dorsum without a well-defined, median, enclosed space; propleurae micropunctate and also with scattered, small punctures; mesopleurae with small, close, somewhat confluent punctures becoming obsolete at the anterior and posterior margins, both of the latter micropunctate; metapleurae micropunctate; sides of propodeum reticulate, the reticulations becoming obsolete anteriorly; tegulae small, glabrous medially and posteriorly, the outer, anterior and inner margins with small punctures and pale pubescence.

Abdomen entirely black, clothed with sparse, pale pubescence throughout, except the last two tergites with fuscous to blackish pubescence; first tergite with small, scattered punctures, the latter sparse but more numerous posteriorly; second tergite with small punctures, close laterally, distinct and separated medially; tergites 3–6 with small, close punctures; last tergite with small, dense, confluent punctures; first sternite flat, closely punctate, without a median, longitudinal carina; second sternite with small, distinct, separated punctures, the latter close at the posterior margin, also with a median, longitudinal carina extending posteriorly from the anterior margin and terminating in a subapical, large, prominent tubercle; sternites 3–6 with small, close punctures posteriorly; hypopygium with a prominent, subarcuate, transverse carina at the anterior margin, with small, close punctures posterior to the carina.

Wings subfuscous; cell 2nd $R_1 + R_2$ broad, the apex of the cell acute and on the costal margin, distinctly longer than cell R + 1st R_1; cell R_5 receiving vein M_{3+4} distinctly before the middle; cell R_4 entirely absent.

Legs piceous to black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Taihorin, Formosa, May, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Easily recognized by the entirely black color and the form of the second sternite and hypopygium. *S. formosana* Zavattari has a similar modification of the second sternite, but neither the carina nor the tubercle are so strongly developed as in *tumidula*.

Squamulotilla formosana (Zavattari).

1913. *Myrmilla formosana* Zavattari, Arch. f. Naturg., 79 (part 3): 21, male.

Lectotype.—Male, Kankau (Koshun), Formosa, V, 1912 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Squamulotilla erdae (Zavattari).

1913. *Mutilla erdae* Zavattari, Arch. f. Naturg., 79 (part 3): 26, female.

Lectotype.—Female, Hoozan, Formosa, I, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Squamulotilla carinulifera (André).

1908. *Mutilla carinulifera* André, Ann. Mus. Nat. Hungarici, 6: 377, female.
1913. *Mutilla carinulifera* Zavattari, Arch. f. Naturg., 79 (part 3): 27, female.

Holotype.—Female, Takao, Formosa, in Hungarian National Museum, Budapest.

Known only from the type specimen. It has been examined and found typical for this genus.

Squamulotilla sauteri (Zavattari).

1913. *Mutilla sauteri* Zavattari, Arch. f. Naturg., 79 (part 3): 27, female.

Lectotype.—Female, Taihorin, Formosa, 1911 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Squamulotilla trituberculata n. sp.

1913. *Mutilla sauteri* Zavattari, Arch. f. Naturg., 79 (part 3): 27, female (in part).

Female.—Head, abdomen, and legs except the coxae and trochanters, black; thorax, coxae and trochanters, ferruginous; lateral margins of dorsum of thorax dentate; thorax with a transverse row of long, vertical teeth at the junction of the dorsal and posterior surfaces; first tergite with a large, transverse, median, apical spot, the second tergite with a moderately broad apical band somewhat broader medially than laterally, white, the color both integumental and pubescent; third tergite with a somewhat obscure median, apical, transverse spot of pale pubescence. Length, 9 mm.

Head entirely black, except the distal two-thirds of the mandibles and the flagellum beneath tinged with ferruginous; mandibles edentate at the apices and with a small tooth within near the apex; clypeus

trituberculate, the tubercles acute, the median one distinctly posterior to the lateral ones; clypeus with fine, close punctures and sparse, short, pale pubescence; first segment of flagellum approximately equal in length to segments two and three united; antennal scrobes distinctly carinate above; front, vertex and genae with moderate, dense, confluent punctures, clothed with sparse, erect, short, dark fuscous pubescence, and scattered, long, erect, black hairs; posterior margin of genae distinctly carinate, the carina terminating ventrally in a small, distinct tubercle; genae with a distinct tubercle anteriorly immediately posterior to the ventral articulation of the mandible; relative widths of head and thorax, 3.8–4.2.

Thorax entirely ferruginous, the dorsum clothed with short, erect, sparse, dark ferruginous pubescence, and scattered, erect, dark hairs, the posterior face with sparse, long, erect, pale hairs, and the pleural areas with sparse, appressed, pale, micropubescence; dorsum with moderate, dense, confluent punctures, the latter slightly larger than on the head, the dorsum thus appearing slightly longitudinally rugoso-punctate; lateral margins of dorsum dentate and denticulate, distinctly excised at the prothoracic and propodeal spiracles; humeral angles distinctly dentate; junction of the posterior and dorsal surfaces with a transverse row of long, vertical teeth; posterior face of propodeum with moderate, close punctures; lateral margins of posterior face of propodeum strongly dentate; anterior margin of propleurae defined by a high, sharp carina; mesopleurae defined posteriorly by a distinct sharp carina; pro-, meso-, and metapleurae indistinctly micropunctate, glabrous; sides of propodeum with moderate, deep, close punctures.

Abdomen entirely black, except the first tergite with a large, median, apical, transverse spot, and the second tergite with a moderately broad, apical band somewhat broader medially, creamy white and with appressed, pale pubescence; narrow lateral margins of second tergite, and a median, apical, transverse spot on the third tergite with pale pubescence, the latter not as conspicuous as the maculations of the first and second tergites; first tergite sparsely punctured anteriorly, the punctures becoming small and dense on the posterior third, clothed with scattered, erect hairs anteriorly, short black pubescence posteriorly; second tergite with small, dense punctures, clothed with sparse, short, black pubescence, scattered, erect, black hairs, and laterally with larger punctures and erect, pale hairs; tergites 3–5 with small, close to dense punctures, clothed with sparse, short, black pubescence and sparse, erect, dark fuscous hairs; last tergite with small, close punctures and clothed with sparse, erect, pale hairs, except the pygidial area glabrous, impunctate; first sternite obscure ferruginous, with small, close punctures, the median carina almost obsolete; second sternite with moderate, separated punctures, scattered, pale pubescence, and a thin, apical fringe of pale hairs; sternites 3–5 with small, close punctures posteriorly, with scattered, pale pubescence, and each with a thin, apical fringe of pale hairs; last tergite with small, dense punctures and sparse, pale pubescence.

Legs black, except the coxae and trochanters ferruginous, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Female, Hoozan, Formosa, March 10 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Closely related to *erdae* Zavattari and may prove to be a subspecies or variety. Both have the trituberculate clypeus; *trituberculata* differs in being distinctly larger, in having the transverse row of teeth on the thorax much more strongly developed, in the presence of the pale pubescent spot on the third tergite, and in the black femora and tibiae.

Genus **Odontomutilla** Ashmead.

Odontomutilla taiwaniana Zavattari.

1913. *Odontomutilla taiwaniana* Zavattari, Arch. f. Naturg., 79 (part 3): 24, female and male.

Holotype.—Female, Taihorin, Formosa, V, 1909 (H. Sauter).

Allotype.—Male, Formosa (H. Sauter). Both holotype and allotype in Zoologisches Museum der Universität, Berlin.

The female sex is related to *cassiope* Smith from Borneo, the latter species and *taiwaniana* being the only described species from the Pacific Islands which do not have a large, anterolateral pubescent fovea on the second tergite. The two species themselves differ in the puncturation of the second tergite and in the color of the legs. This is the only species described from the Pacific Islands in which the male does not have the posterolateral angles of the propodeum produced and angulate; in the male of *taiwaniana* the posterolateral angles are evenly rounded.

Genus **Timulla** Ashmead.

Subgenus **Trogaspidia** Ashmead.

Bradley and Bequaert (1923 and 1928) have reduced *Trogaspidia* Ashmead to a subgenus of *Smicromyrme.* This disposition of the genus *Trogaspidia* does not seem warranted to me. Bradley and Bequaert indicate in their discussion (1923) and in their key (1928) that the only basis for the distinguishing of the males of these two groups is the relative lengths of the first two segments of the flagellum. I agree that if no other basis exists for separating the two groups than this flagellar character, then *Trogaspidia* can not be maintained as generically distinct from *Smicromyrme.* There are, however, three perfectly good structural features which serve to distinguish the males. Two of these I have indicated in the key to genera at the beginning of this paper. First,

the shape of the vertex of the head, which in *Smicromyrme* males is elevated posteriorly, flattened, truncate at the posterior margin, and longitudinally striatopunctate throughout. Second, in *Smicromyrme* males the distance between the origin of vein M on vein R and the base of the stigmatic cell is equal to twice the length of the latter; in *Trogaspidia* this distance is equal to or less than the length of the stigmatic cell. I have examined the genotype species of both groups and find these characters hold for the genotypes as well as all other species I have examined. An examination of the genitalia of the two groups also discloses differences in structure much greater than that found between the species of either group. The differences in the females are not so obvious, although there seems to be a fundamental difference in the pattern of the pubescent markings of the second tergite. In *Trogaspidia* females the pale pubescent markings are always paired, while in *Smicromyrme* females the pubescent markings are not paired, the second tergite bearing none, one or three pale pubescent spots. For these reasons I regard *Trogaspidia* as distinct from *Smicromyrme*. A number of the other genera placed as subgenera of *Smicromyrme* by Bradley and Bequaert probably ought to be removed along with *Trogaspidia* and either maintained at equal rank with the latter or reduced to sections within *Trogaspidia*.

Although there are good structural grounds for maintaining *Trogaspidia* distinct from *Smicromyrme*, I have been unable to find any for distinguishing *Trogaspidia* from the new world genus *Timulla*. There appear to be no features of body structure, wing venation or genitalia which will differentiate the two. I have examined carefully the dissected genitalia of species belonging to each group and the differences to be seen are similar in character and degree to those found in different species of either *Trogaspidia* or *Timulla*. I am inclined to the view that *Timulla* (that name having priority) is the only Mutillid genus having a world-wide distribution, the Palearctic, Ethiopian, Oriental and Australian representatives having formerly been regarded as belonging to *Trogaspidia*. For convenience sake I still retain *Trogaspidia* here as of subgeneric rank, but purely on geographical grounds. I know of no structural features in either sex which will separate the two groups, with the possible exception of the pubescent pattern of the second tergite in the females; in the subgenus *Timulla* the pale pubescent markings of the second tergite are

generally linear, while in *Trogaspidia* they are generally circular or subcircular.

KEY TO THE MALES OF TIMULLA.

1. Hypopygium with lateral, elevated ridges terminating in a distinct tubercle; scutellum distinctly gibbose 2
   Hypopygium simple, without ridges or tubercles; scutellum not gibbose 8
2. Mandibles deeply excised beneath 3
   Mandibles not excised beneath. (Page 391) ... **philippinensis** subsp. **amartana**
3. Clypeus with a prominent, transverse, submarginal carina anteriorly extending from one side to the other. (Page 395) ..... **elpinice**
   Clypeus not transversely carinate anteriorly 4
4. Last tergite with a narrow, median, glabrous area, the latter not tumescent, and terminating in a low, blunt distinct tubercle. (Page 398) ..... **disparilis**
   Last tergite with a broad, median, tumescent, glabrous area, the latter rounded off posteriorly, not terminating in a tubercle 5
5. First two abdominal segments entirely ferruginous 6
   First abdominal segment more or less, at least the first sternite, black or blackish 7
6. Clypeus nearly flat, with a median, longitudinal, slightly elevated ridge extending from the posterior margin anteriorly to the submarginal impressed line; abdominal segments 1–5, ferruginous. (Page 400) .. **denotata**
   Clypeus distinctly, transversely concave anteriorly, elevated along the median line only slightly on the posterior half; abdominal segments 1–6 ferruginous. (Page 402) ..... **concava**
7. Ocelli small, the distance between the eye margins and the lateral ocelli equal to three or four times the greatest diameter of the latter; hypopygial ridges widely separated, the distance between their tips equal to their length; longitudinal clypeal ridge low, the clypeus almost flat; abdominal segments 2–5 entirely ferruginous. (Page 404), **suspiciosa** subsp. **discolor**
   Ocelli large, the distance between the eye margins and the lateral ocelli equal to twice the greatest diameter of the latter; hypopygial ridges approximate, the distance between their tips about half their length; longitudinal clypeal carina high and prominent; only abdominal segments 2 and 3, ferruginous. (Page 406) ..... **rhea**
8. Thorax largely ferruginous. (Page 408) ..... **rapa**
   Thorax entirely black 9
9. Abdominal segments 1–4 ferruginous. (Page 408), **orientalis** subsp. **taiwanensis**
   Head, thorax and abdomen entirely black 10
10. Third abdominal tergite clothed entirely with dense, appressed, pale golden pubescence. (Page 410) ..... **gutrunae**
    Third abdominal tergite with only an apical band of sparse, pale pubescence 11
11. Fourth abdominal tergite with only scattered, erect, pale hairs, not conspicuously pale pubescent like the third; tegulae largely testaceous. (Page 410) ..... **friekae**
    Fourth abdominal tergite with erect and semi-recumbent, pale pubescence like the third; tegulae blackish. (Page 410) .... **friekae** subsp. **discrepans**

KEY TO THE FEMALES OF TIMULLA.

1. Pygidium longitudinally striate 2
   Pygidium sculptured otherwise 3
2. Fourth tergite entirely black pubescent; second tergite with a distinct, narrow, apical band of pale pubescence interrupted medially with black. (Page 413) ..... **minae**
   Fourth tergite with a broad band of dense, silvery pubescence, distinctly interrupted medially with black; apical margin of second tergite black pubescent. (Page 414) ..... **repraesentans** subsp. **taihorina**

3. Apical margin of second tergite with a complete or incomplete band of pale pubescence 4
   Apical margin of second tergite entirely black pubescent 5
4. Narrow, apical, pale pubescent band of second tergite complete; pygidial area delicately, longitudinally rugose on the basal half. (Page 413) ... **logei**
   Narrow, apical, pale pubescent band of second tergite present medially but interrupted laterally; pygidial area very delicately rugose, mostly glabrous. (Page 413) ..... **pfafneri**
5. Tergites 3 and 4 clothed with pale, appressed pubescence, both narrowly interrupted medially with black; legs entirely black. (Page 411), **repraesentoides**
   Tergite 3 with a complete band, tergite 4 with a pair of lateral, transverse spots, all of pale pubescence; proximal two-thirds of anterior femora ferruginous, the proximal half of the middle and posterior femora usually distinctly ferruginous. (Page 391) .. **philippinensis** subsp. **amartana**

Timulla (Trogaspidia) philippinensis subsp. **amartana** (Zavattari).

1913. *Mutilla amartana* Zavattari, Arch. f. Naturg., Vol. 79 (3): 28, female and male.

Zavattari (1910 and 1913) has pointed out that *Mutilla dimidiata* Sichel and Radoskowski, *M. dimidiata* Magretti, and *M. dimidiata* Bingham are not conspecific with *Mutilla dimidiata* Lepeletier = *Timulla* (*Trogaspidia*) *orientalis* Mickel. He therefore (1913) suggested the name *amartana* for the species determined by the above authors as *dimidiata*. He also listed thirteen specimens from Formosa as the species *amartana*, but failed to designate any sort of a type or type locality for the species. The specimens referred by Zavattari to *amartana* are peculiar to Formosa and are certainly not the same as any of the forms referred to *dimidiata* by Sichel and Radoskowski, Magretti and Bingham. The specimens recorded by the latter authors came from several other localities and represent probably two, and possibly three different species. Since no type locality was chosen and Zavattari labeled his specimens "Mutilla amartana Zavattari," I herewith designate Formosa as the type locality, and choose the following specimens as lectotype, allotype and paratypes, respectively.[2]

Lectotype.—Female, Taihauroku, Formosa, August 3–10, 1908 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Allotype.—Male, Taihauroku, Formosa, August 3–10, 1908 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—Male, Taihorin, August 7, 1911 (H. Sauter); female, Taihorin, August, 1910 (H. Sauter); male, Taihorin,

[2]I am indebted to Dr. C. W. Stiles, Secretary of the International Commission of Zoological Nomenclature, for advice regarding the designation of the type locality and lectotype of *amartana* Zavattari.

October, 1910 (H. Sauter); male, Taihorinsho, September, 1910 (H. Sauter); male, Pilam, July, 1912 (H. Sauter); two females, Kosempo, October, 1911 (H. Sauter); female, Kankau (Koshun), April, 1912 (H. Sauter); female, Taihorin (H. Sauter). Paratypes in Zoologisches Museum der Universität, Berlin; Deutsches Entomologisches Institut, Berlin-Dahlem; Zoological Institute, University of Turin, Italy; and University of Minnesota, U. S. A.

As stated elsewhere *dimidiata* Sichel and Radoskowski, 1869, Magretti, 1892, and Bingham, 1897, are therefore still without a name, but since their material is not at present available for examination and the possibility exists that three species may be involved, I prefer to leave them thus until some definite knowledge can be had of them.

The description of the lectotype and allotype are as follows:

Female.—Head and abdomen black, the thorax entirely ferruginous; second tergite with a pair of anterior, large, somewhat ovate spots, the third tergite with a complete transverse band, and the fourth tergite with a pair of lateral, transverse spots, not extending to the lateral margins, all very pale golden pubescent; pygidial area irregularly rugose; proximal portion of femora more or less ferruginous. Length, 14 mm.

Head entirely black, the front and vertex clothed with sparse, pale fuscous pubescence, the genae with sparse, pale pubescence; proximal half of mandibles ferruginous, the distal half black, edentate at the apex and with a small tooth within; clypeus strongly, transversely elevated posteriorly; antennal tubercles black; first segment of flagellum subequal in length to the second and third united; antennal scrobes distinctly carinate above; front, vertex and genae with moderate, dense, deep, confluent punctures, the genae somewhat less coarsely sculptured than the front and vertex, relative widths of head and thorax, 5.7–5.6.

Thorax entirely ferruginous; dorsum clothed with sparse, erect and recumbent, ferruginous pubescence; posterior face of propodeum clothed with sparse, erect, pale hairs; pleural areas finely micropubescent; lateral margins of dorsum constricted at the mesonotal area, relative widths at humeral angles, anterior spiracles, middle of mesonotum, and scutellar scale, 5.4–5.6–5.0–5.6; humeral angles distinctly angulate; scutellar scale well developed; dorsum with large, dense, confluent punctures becoming reticulate on the posterior face of propodeum; lateral margins of propodeum dentate; anterior margin of propleurae defined by a carina; propleura with moderate, shallow, indistinct punctures; meso-, and metapleurae micropunctate; sides of propodeum with sparse, moderate, shallow, indistinct punctures.

Abdomen black, the second tergite with a pair of large, anterior, subovate spots, posterior half of lateral margins of second tergite, third

tergite with a broad, complete, transverse band, fourth tergite with a pair of large, transverse, lateral spots not extending to the lateral margins, all with dense, appressed, very pale golden pubescence; lateral margins of last tergite, and apical fringes of sternites 2–5, all with pale pubescence; first tergite with appressed, black pubescence and sparse, erect, pale hairs, the apical margin black; second tergite with black, appressed and erect pubescence, except as above noted, and the latero-anterior areas with sparse, erect, pale hairs, the apical margin entirely black; fourth and fifth tergites with black, appressed pubescence, except as above noted, and scattered, erect, pale hairs; pygidial area irregularly rugose throughout; first sternite with a median, longitudinal carina on the anterior half; second sternite with moderate, separated punctures, becoming smaller and closer at the posterior margin, and with sparse, erect, pale hairs; tergites 3–5 and hypopygium with scattered, moderately small punctures anteriorly, becoming close and confluent at the posterior margin.

Anterior femora except the tips, proximal two-thirds of intermediate femora, and proximal half of posterior femora, all ferruginous, the remainder of the legs black; clothed throughout with sparse, erect and appressed, pale pubescence; calcaria pale.

Male.—Head, thorax, first and last abdominal segments and legs, black; abdominal segments 2–6, ferruginous; front, pronotum and dorsum of propodeum with conspicuous, appressed, pale pubescence; mandibles neither emarginate nor toothed beneath; scutellum strongly elevated medially; last tergite with a median, longitudinal, glabrous area; hypopygium with lateral, elevated ridges. Length, 20 mm.

Head entirely black; front with somewhat dense, appressed, and sparse, erect, pale pubescence, the vertex with sparse, erect, pale pubescence, the genae with sparse, erect and appressed, pale pubescence; mandibles rather broad, edentate at the apex and with a distinct, subapical tooth within, beneath somewhat concave but not emarginate and without a tooth beneath near the base; clypeus with a large, median, slightly concave, subpentagonal, glabrous area, the latter slightly but distinctly elevated along the median longitudinal line, and with a transverse, submarginal row of confluent punctures anteriorly; clypeal fringe pale; antennae entirely black; scape bicarinate beneath, clothed with sparse, pale pubescence; first segment of flagellum subequal in length to the second; antennal scrobes carinate above; front and vertex with moderately large, close, confluent punctures; genae with moderate, close punctures, not as coarsely sculptured as the front and vertex; ocellar area distinctly elevated; a small glabrous, impunctate area immediately posterolaterad of each lateral ocellus; relative widths of head and thorax including the tegulae, 6.9–8.8.

Thorax entirely black; pronotum, dorsum of propodeum and mesopleurae medially, with dense, appressed, pale pubescence; mesonotum with sparse, recumbent, black pubescence; anterior half of scutellum with sparse, erect, black pubescence, the posterior half with sparse, erect, pale pubescence; posterior face and sides of propodeum with sparse, erect, pale pubescence; pronotum with moderately large, dense,

deep, confluent punctures; mesonotum longitudinally rugosopunctate, the punctures large and confluent, and with a median, longitudinal, glabrous, slightly raised line; parapsidal furrows very deep; scutellum conically elevated, the apex of the elevation broad and glabrous, otherwise the scutellum with large, deep, dense, confluent punctures; dorsum and posterior face of propodeum reticulate, the former with a distinct, median, enclosed area, broad and parallel-sided for a short distance at the base, then gradually narrowed to the apex which is angular, the enclosed space with a median, longitudinal carina anteriorly; propleurae defined anteriorly by a carina, transversely striatopunctate, the striae not extending to the posterior margin; mesopleurae somewhat elevated dorsally and ventrally, the elevations separated by a transverse depression, the whole with moderately large, dense, confluent punctures; metapleurae micropunctate and pubescent dorsally, with moderate, close, shallow punctures on the ventral half; sides of propodeum shallowly reticulate; tegulae large, margined posteriorly and on the external margin, glabrous, impunctate, except the anterior and inner margins punctate and black pubescent.

First abdominal segment, except broad, apical margin of first tergite, and last abdominal segment entirely, black; first tergite with moderate, separated punctures and sparse, erect, pale hairs, except the apical margin with small, close punctures, and a thin, apical fringe of pale golden hairs; second tergite glabrous and almost impunctate along the median longitudinal and transverse lines, the lateral areas with moderate, close, confluent punctures anteriorly, the latter becoming more separated and smaller posteriorly; second tergite clothed throughout with sparse, erect, pale hairs, and the apical margin with a thin fringe of golden pubescence; tergites 3–6 with small, separated punctures and sparse, erect, golden pubescence, each with an apical fringe of golden pubescence; last tergite laterally with small, close confluent punctures, medially with a broad, tumescent, glabrous area not terminating in a tubercle or at a carina; lateral areas of last tergite with suberect, black pubescence, and scattered, erect, pale hairs; first sternite with a median, longitudinal carina on the anterior two-thirds, slightly elevated at the posterior end to form a tooth; second sternite with large, shallow, rather close punctures, but very sparse medially, clothed with sparse, very pale golden pubescence; sternites 3–6 with small, separated punctures and sparse, very pale golden pubescence; sternites 2–6 each with a very thin, apical fringe of pale golden pubescence; sternite 6 with a pair of small, almost obsolete, lateral tubercles near the posterior margin; hypopygium with a pair of distinct lateral tubercles anteriorly and a pair of prominent, longitudinal, lateral ridges, each terminating in a small, blunt tooth.

Wings fuliginous throughout; cell R + 1st R_1 equal in length to 2nd R_1 + R_2; cell R_5 receiving vein M_{3+4} five-eighths the distance from base to apex; cell R_4 present, but less distinct than R_5, hexagonal in shape, receiving vein M_2 two-thirds the distance from base to apex; cell 2nd R_1 + R_2 subtruncate at the apex.

Legs entirely black, clothed with sparse, pale pubescence; calcaria pale.

Amartana is one of a group of subspecies including *malayana* Cameron (female = *skeati* Cameron), *philippinensis* Smith (male = *bicolor* Ashmead), and *itambusa* Cockerell. All are characterized by mandibles, clypeus and last abdominal segment as described above. Since *philippinensis* is the oldest name, the species must bear that name; the subspecies are then *amartana* from Formosa, *malayana* from the east coast of the lower Malay peninsula, *philippinensis* from the Philippine Islands and *itambusa* from the Philippine Islands. *Amartana* is most closely related to *malayana* Cameron since it bears pale pubescence on the front, pronotum and dorsum of propodeum; I have not been able to compare specimens of *malayana* with *amartana* so can only point out that the female of *malayana* differs from *amartana* by the fourth abdominal tergite bearing a broad fascia of appressed, pale pubescence interrupted medially with black, and in having all the femora except the apices, ferruginous, while the male of *amartana* has the front less densely pale pubescent than *malayana*. There can be no doubt of their subspecific distinctness and a comparison of actual specimens would enable one to point out more definite differential characters than can be done from the description of *malayana* alone. The female of the subspecies *philippinensis* differs from both the above by having the fourth abdominal tergite entirely black pubescent, while the male differs in having the pubescence of the front, pronotum, dorsum of propodeum and all the abdominal segments black, and with only abdominal segments 2–5 ferruginous, 1, 6 and the last being black; the subspecies *itambusa* differs from all in having the abdomen entirely black.

I have seen no specimens from the Asiatic mainland, other than the southern Malay peninsula, that belong with this group of subspecies, although it is well within the realm of possibility that such forms exist in Siam, Annam, China, Burma and even India.

Timulla (Trogaspidia) elpinice n. sp.

1913. *Mutilla analis* Zavattari, Arch. f. Naturg., Vol. 79 (3): 41, male (in part) (nec Lepeletier).

Male.—Head, thorax, last two abdominal segments and legs black; abdominal segments 1–5 entirely ferruginous; mandibles deeply excised beneath; clypeus anteriorly with a prominent, transverse, submarginal carina, extending from one side to the other; scutellum only very slightly

gibbose; tergites 4 and 5 each with a transverse band of appressed, pale golden pubescence, that on the 5th most conspicuous; last tergite with a narrow, median, elongate, glabrous, impunctate area terminating posteriorly in a short, longitudinal carina; lateral ridges of hypopygium low, not terminating in a tubercle or tooth. Length, 10.5 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence; anterior half of front with dense, appressed, pale pubescence, and the genae with sparse, short, appressed, pale pubescence in addition to the erect pubescence; mandibles black, tinged with ferruginous subapically, deeply emarginate beneath and with a large tooth near the base, slightly broadened towards the apex, edentate at the tip and with a distinct tooth within near the apex; clypeus with a prominent, transverse, submarginal carina extending from one side to the other, the area anterior to the carina glabrous, obscurely punctate and sparsely pubescent, the median area posterior to the carina glabrous, impunctate, except at the posterior extreme medially punctate and sparsely pubescent; scape distinctly bicarinate beneath, clothed throughout with sparse, pale pubescence, the apex of the scape above slightly tinged with dark ferruginous; first and second segments of flagellum approximately equal in length; antennal scrobes distinctly carinate above; front and vertex with moderate, dense, confluent punctures, the genae with moderately small, dense, confluent punctures; ocelli small, the distance between the eye margins and the lateral ocelli about four times the diameter of the latter; relative widths of head and thorax, including the tegulae, 3.85–4.80.

Thorax entirely black, clothed throughout with sparse, erect, pale pubescence, except the posterior half of mesonotum and anterior half of scutellum with sparse, erect and recumbent blackish pubescence, the pronotum also with a broad, marginal band of dense, appressed, pale golden pubescence posteriorly, the dorsum of propodeum also with sparse, fine, inconspicuous, semiappressed, pale pubescence, and the mesopleurae medially with thicker, pale pubescence; pronotum and mesonotum with moderate, dense, deep, confluent punctures, the parapsidal furrows on the mesonotum deep and distinct on the posterior half; scutellum mostly convex, only very slightly gibbose, with a median, broad, longitudinal, glabrous line on the anterior half, the line rounded off posteriorly, not terminating in an elevation; dorsum of propodeum and posterior face distinctly reticulate; dorsum of propodeum with a median, enclosed space, about twice as long as broad at the base, the posterior two-thirds considerably narrower than the anterior third, the sides sinuate, and the enclosed space terminating at a median, longitudinal, sinuate carina extending the length of the posterior face of propodeum; propleurae transversely striatopunctate, the striae not extending to the posterior margin; mesopleurae with moderately large, shallow, dense, confluent punctures except anteriorly, the anterior area micropunctate; metapleurae micropunctate except the ventral third and the posterior margin with moderate, shallow, close punctures; sides of propodeum moderately reticulate, except the anterior third micropunctate; tegulae glabrous, impunctate, except the anterior and

inner margins punctate and pale pubescent; posterior margin of tegulae slightly reflexed.

Abdomen ferruginous, except the last two segments black, clothed throughout with sparse, erect, pale pubescence, the fourth and fifth tergites also with a broad, apical band of dense, appressed, pale golden pubescence, obscurely interrupted medially, that on the fourth less conspicuous than the fifth, and the sixth tergite and basal half of the last tergite also with sparse, recumbent, black pubescence; first tergite with moderate, scattered, shallow punctures, except the posterior margin with a line of small, close punctures; second tergite with the posterolateral areas slightly but distinctly elevated, the posterior margin laterally conspicuously depressed and with moderate, close punctures laterally, becoming sparse and practically impunctate at the mid-line; tergites 3–6 with moderately small, close punctures; last tergite with small, dense punctures, except a median, elongate, narrow, glabrous, impunctate area terminating posteriorly in a short, longitudinal, distinct carina; first sternite with a median, longitudinal carina on the basal two-thirds, the carina sharp and gradually elevated posteriorly forming a low, acute tooth at its posterior terminus; second sternite with moderately large punctures, close laterally, becoming separated, distinct and sparse towards the middle; sternites 3–6 with small, close punctures at the apical margin; sternite 6 without lateral tubercles; sternite 7 with obscure, lateral, elongate, glabrous tubercles; hypopygium with a pair of lateral, distinct, low, slightly converging, glabrous ridges, rounded off posteriorly, not terminating in a tubercle or tooth, the space between the ridges finely, densely punctate.

Wings subfuscous, except cell M hyaline; cell 2nd $R_1 + R_2$ subtruncate at the apex, equal in length to cell R + 1st R_1; cell R_5 receiving vein M_{3+4} at two-thirds the distance from base to apex; cell R_4 almost obsolete, receiving vein M_2 at two-thirds the distance from base to apex.

Legs entirely black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Takao, Formosa, June 23, 1907 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratype.—Male, Formosa (Haberer), in University of Minnesota.

The transverse, submarginal, clypeal carina, and the bands of appressed, pale golden pubescence on abdominal tergites four and five distinguish this species at once from all other Formosan species of this genus. *Elpinice* is closely related to *pustulata* Smith from Japan, which has the clypeus almost identical, but differs in having much stronger hypopygial ridges which terminate in distinct teeth and which has abdominal segments 3–7 entirely black, the third and fourth tergites with apical bands of pale pubescence.

Timulla (Trogaspidia) disparilis n. sp.

1913. *Mutilla analis* Zavattari, Arch. f. Naturg., Vol. 79 (3): 41, male (in part) (nec Lepeletier).

Male.—Head, thorax, last two abdominal segments and legs black, abdominal segments 1–5 entirely ferruginous; scape beneath, front medially, pronotum lateroposteriorly, dorsum of propodeum, mesopleurae medially, and fifth abdominal tergite, all with dense, appressed, pale pubescence; mandibles emarginate and toothed beneath near the base; median area of clypeus large, very slightly concave, without any trace of a median longitudinal ridge, glabrous, impunctate throughout; last tergite with a narrow, median, impunctate, glabrous area terminating posteriorly in a low inconspicuous tubercle; hypopygium with a pair of lateral, slightly converging elevated ridges. Length, 12.5 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence; the front medially with dense, appressed, pale pubescence, the vertex posteriorly, and the genae with sparse, appressed, pale pubescence in addition to the erect pubescence; mandibles comparatively slender, edentate at the tip and with a small tooth within near the apex, deeply emarginate beneath and with a large tooth near the base; clypeus as mentioned above; scape obscurely bicarinate beneath, clothed with sparse, pale pubescence, except beneath with dense, appressed, pale pubescence; first and second segments of flagellum approximately equal in length; antennal scrobes distinctly carinate above; front, vertex and genae with moderate, dense, confluent punctures; ocelli small, the distance between the eye margins and the lateral ocelli approximately four and one-half times the diameter of the latter; relative widths of head and thorax including the tegulae, 4.5–5.3.

Thorax entirely black, clothed throughout with sparse, erect, pale pubescence, except the mesonotum and anterior half of scutellum with sparse, erect and appressed, black pubescence, the lateroposterior, triangular areas of pronotum with dense, appressed, pale golden pubescence, and the dorsum of propodeum and mesopleurae medially with dense, appressed, pale pubescence; pronotum and mesonotum with moderate, dense, deep, confluent punctures; parapsidal furrows on mesonotum deep and distinct; scutellum with moderately large, dense, deep, confluent punctures, moderately gibbose, the anterior half with a wide, median, longitudinal, glabrous line, terminating at the apex of the elevation; dorsum of propodeum and posterior face deeply, broadly reticulate, the dorsum separated from the posterior face by a transverse, sinuate carina; dorsum of propodeum with a median, enclosed area, slightly wider anteriorly than posteriorly, about two and one-fourth times as long as broad; propleurae transversely striatopunctate, the striae not extending to the posterior margin; mesopleurae with moderate, dense, confluent punctures, deepest medially, shallow at the posterior margin and obsolete anteriorly, the anterior submarginal region micropunctate; metapleurae micropunctate, except ventrally with shallow, close punctures; sides of propodeum shallowly reticulate, becoming obsolete anteriorly; tegulae glabrous, impunctate,

except the anterior and inner margins punctate and black pubescent, the posterior margin slightly reflexed.

Abdomen ferruginous, except the last two segments black; clothed throughout with sparse, erect, pale pubescence, the fifth tergite also with thick, appressed, pale golden pubescence, the sixth and last tergites also with short, recumbent, sparse, black pubescence; first tergite with sparse, moderate punctures, except the posterior margin with small, close punctures; second tergite with moderate, close punctures laterally, becoming sparse medially, the median area impunctate; tergites 3–6 with moderately small, close but mostly distinct punctures; last tergite with moderately small, dense, confluent punctures laterally, medially with a narrow, elongate, glabrous, impunctate area, terminating before the apical margin in a low, inconspicuous tubercle; first sternite with a median, longitudinal carina on the anterior two-thirds, second sternite with moderately large punctures, sparse medially, close laterally; sternites 3–6 with moderately small, close punctures posteriorly; sternite 6 with a pair of small, glabrous, almost obsolete, posterolateral tubercles; sternite 7 with a pair of distinct, elongate, lateral tubercles; hypopygium with a pair of prominent, lateral, slightly converging ridges on the anterior two-thirds, each terminating in a distinct tubercle, the area between the ridges with small, dense, confluent punctures.

Wings subfuscous, except cell M hyaline; cell 2nd $R_1 + R_2$ distinctly truncate at the apex, slightly longer than cell R + 1st R_1; cell R_5 receiving vein M_{3+4} slightly but distinctly beyond the middle; cell R_4 present but less distinct than R_5 and receiving vein M_2 about two-thirds the distance from base to apex.

Legs entirely black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Taihorin, Formosa, June, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—3 males, Taihorin, April, 1910 (H. Sauter); 4 males, Taihorin, June, 1910 (H. Sauter); male, Takao, June 1, 1907 (H. Sauter); male, Takao, June 8, 1908 (H. Sauter); and male, Takao, July 2, 1907 (H. Sauter); in Zoologisches Museum der Universität, Berlin, and University of Minnesota, U. S. A.

This species is entirely different from *analis* Lep. and from other specimens determined by Zavattari as *analis* by the form of the clypeus, the form of the glabrous area on the last tergite, i. e., terminating in a low tubercle, and in the dorsum of the propodeum separated from the posterior face by a transverse sinuate carina. Other characteristic features are the obscurely bicarinate scape with dense, pale pubescence beneath, the pale golden pubescence of the front restricted to the median area and not extending to the margin of the eyes, the pale golden pubescence of the pronotum restricted to lateral areas and not present medially, and the noticeable appressed, pale

pubescence of the fifth tergite. The paratypes vary in length from 9.5 mm. to 12.5 mm.

Timulla (Trogaspidia) denotata n. sp.

1913. *Mutilla analis* Zavattari, Arch. f. Naturg., Vol. 79 (3): 41, male (in part) (nec Lepeletier).

Male.—Head, thorax, legs and last two abdominal segments black; abdominal segments 1–5 entirely ferruginous; mandibles deeply excised beneath near the base; median area of clypeus slightly elevated, triangular in outline, with a low, median, longitudinal ridge terminating anteriorly before the anterior margin, entirely glabrous throughout; ocelli small, the distance between the inner margins of the eyes and the lateral ocelli three times the diameter of the latter; scutellum elevated, with a broad, median, longitudinal, glabrous line on the anterior half. Length, 15 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence, the lateral portions of clypeus and anterior two-thirds of front also with dense, appressed, pale pubescence, and the genae also with sparse, appressed, pale pubescence; mandibles bidentate, deeply excised beneath near the base, forming a strong tooth; median, slightly elevated area of clypeus large, subtriangular in outline, with a median, low, longitudinal ridge extending from the posterior margin anteriorly to a submarginal transverse sulcus, entirely glabrous, impunctate throughout; scape distinctly bicarinate beneath, clothed with sparse, pale pubescence; first and second segments of flagellum approximately equal in length; antennal scrobes carinate above; front with moderate, close, confluent punctures; vertex with moderate, close but distinct punctures, the genae with moderately small, close, distinct punctures; ocelli small, the distance between the eye margins and the lateral ocelli equal to three times the diameter of the latter; relative widths of head and thorax including the tegulae, 5.0–5.7.

Thorax entirely black, the pronotum and mesopleurae with dense, appressed, pale pubescence, the dorsum of propodeum with thick, semirecumbent, pale pubescence, the mesonotum and anterior half of scutellum with erect and recumbent black pubescence, otherwise with sparse, erect, pale pubescence; pronotum with moderate, dense, confluent punctures, the parapsidal furrows deep and prominent; scutellum with moderate, dense, deep, confluent punctures, elevated medially, and with a broad, glabrous line on the anterior half terminating at the apex of the elevation; dorsum of propodeum, and the posterior face, broadly reticulate, the dorsum with a median enclosed space about three times as long as broad at the base, the sides somewhat sinuate and gradually converging to a rounded apex, the latter meeting a median, longitudinal carina extending the length of the posterior face; propleurae transversely striatopunctate, the striae not reaching the posterior margin; mesopleurae with moderate, close, confluent punctures, the latter becoming shallow and obsolete at the anterior and posterior margins, the whole surface of the mesopleurae micropunctate as well; metapleurae micropunctate and micropubescent except for shallow, close punctures

ventrally; sides of propodeum shallowly reticulate, the reticulations becoming obsolete anteriorly; tegulae black, glabrous throughout except the anterior and inner margins punctate and black pubescent.

Abdomen ferruginous, except the last two segments black, and the extreme anterior portion of the first segment tinged with black; segments 1–5 with sparse, erect, pale ferruginous pubescence both above and beneath, each tergite with a thin apical fringe of ferruginous pubescence and each sternite with a similar apical fringe of pale pubescence; tergite 6 and the pygidial tergite clothed with sparse, erect, black pubescence, the apical fringe of 6 black; sternite 6 and the hypopygium with sparse, erect, pale to pale fuscous pubescence; first tergite with moderate, scattered punctures, becoming closer and smaller posteriorly; second tergite with moderate, close, distinct punctures laterally becoming impunctate and glabrous medially; tergites 3–6 with moderate, distinct punctures; pygidial tergite with a median, glabrous, longitudinal impunctate area, broader posteriorly than anteriorly, not terminating in an elevation but rounded into the apical portion of the tergite; first sternite with a median, longitudinal carina on the anterior two-thirds, elevated at its posterior terminus into a small tooth; lateral, and anterolateral areas of second sternite with moderately large, shallow, distinct punctures, the sternite medially and apically glabrous, very sparsely punctate; sternites 3–6 with small, close punctures towards the apical margin; sternite 6 with a pair of elongate, lateral, converging, almost obsolete tubercles near the posterior margin; sternite 7 distinct and with a distinct, elongate tubercle at each posterolateral angle; hypopygium with a pair of strongly elevated, lateral, converging posteriorly ridges terminating in a distinct tooth.

Wings subfuscous, except cell M almost hyaline; cell 2nd $R_1 + R_2$ distinctly truncate at the apex, slightly longer than cell R + 1st R_1; cell R_5 receiving vein M_{3+4} at about two-thirds the distance from base to apex; cell R_4 present, but less distinct than R_5, hexagonal, receiving vein M_2 at two-thirds the distance from base to apex.

Legs entirely black, clothed with sparse, erect, pale pubescence; calcaria pale.

Holotype.—Male, Formosa (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—Two males, Taihorin, March, 1910 (H. Sauter); six males, Taihorin, June, 1910 (H. Sauter); two males, Taihorin, August, 1911 (H. Sauter); male, Taihorinsho, September (H. Sauter); male, Taihorinsho, September, 1910 (H. Sauter); male, Taihorinsho, November, 1909 (H. Sauter); male, Taihorinsho, November, 1910 (H. Sauter); male, Taihanroku, August, 1908 (H. Sauter); male, Hoozan, November, 1910 (H. Sauter); five males, Kankau (Koshun), April, 1912 (H. Sauter); male, Kankau (Koshun) May, 1912 (H. Sauter); male, Formosa (H. Sauter); in Zoologisches Museum der Universität, Berlin, Deutsches Entomologisches Institut, Berlin-Dahlem, Dr. H.

Hedicke collection, Berlin, Zoological Institute, University of Torino, Italy, and University of Minnesota, U. S. A.

I have examined Lepeletier's type of *analis* in the University of Torino, Italy, and have compared Zavattari's specimens from Formosa with it. The type differs from all of these Formosa specimens in having much larger ocelli and in other less obvious characters. In examining all the described species from the Oceanic Islands I have found none similar to *analis* Lepeletier. The majority of the specimens referred to *analis* by Zavattari are representatives of the species described above.

Timulla (Trogaspidia) concava n. sp.

1913. *Mutilla analis* Zavattari, Arch. f. Naturg., Vol. 79 (3): 41, male (in part) (nec Lepeletier).

Male.—Head, thorax, last abdominal segment, and legs, black; abdominal segments 1–6 entirely ferruginous; mandibles deeply excised beneath; clypeus with a large, median, subhexagonal area, transversely concave anteriorly, glabrous and impunctate; ocelli small; scutellum gibbose; hypopygium with a pair of elevated, lateral converging ridges. Length, 14 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence, the lateral portions of clypeus, and front anterior to middle ocellus also with dense, appressed, pale pubescence, the genae and posterior portion of vertex also with fine, short, sparse, appressed, pale pubescence; mandibles rather broad apically, bluntly edentate at the tip and with a distinct tooth within near the apex, deeply excised beneath near the base; clypeus with a large, median, subhexagonal, glabrous, impunctate area, distinctly transversely concave anteriorly, also with a submarginal, transverse, impressed, punctate line anteriorly, and with a slightly elevated, median, longitudinal line only on the posterior half; scape bicarinate beneath, clothed with sparse, pale pubescence; first and second segments of flagellum approximately equal in length; antennal scrobes weakly carinate above; front and vertex with moderate, shallow, close punctures, the genae with moderately small, close but mostly distinct punctures; ocelli small, the distance between the inner eye margins and the lateral ocelli equal to about four times the diameter of the latter; a small, glabrous area posterolaterad of each lateral ocellus; relative widths of head and thorax including the tegulae, 4.7–5.7.

Thorax entirely black, clothed throughout with sparse, erect, pale pubescence, except the mesonotum and anterior half of scutellum with erect and recumbent, sparse, black pubescence, the pronotum, dorsum of propodeum and mesopleurae also with dense, appressed, pale pubescence; pronotum with moderate, dense, deep, confluent punctures; mesonotum with moderate, close, confluent punctures, the parapsidal furrows deep; scutellum gibbose, with moderate, dense, deep, confluent punctures, and with a broad, glabrous, median, longitudinal line on the anterior half terminating at the apex of the elevation; dorsum of pro-

podeum and posterior face distinctly reticulate, the dorsum with a median enclosed space about three times as long as broad at the base, the sides slightly converging and the apex rounded; propleurae transversely striatopunctate, the striae not reaching the posterior margin; mesopleurae with moderate, dense, confluent punctures medially, micropunctate anteriorly and posteriorly; metapleurae micropunctate and micropubescent except for shallow, moderate punctures ventrally; sides of propodeum shallowly reticulate, the reticulations becoming obsolete anteriorly; tegulae glabrous, impunctate except the anterior and inner margins punctate and black pubescent.

Abdomen entirely ferruginous, except the last segment black; tergites 1–6 with sparse, erect, pale ferruginous pubescence, and each with a thin, apical fringe of ferruginous pubescence; last tergite clothed with blackish pubescence; first tergite with large, shallow, close punctures, except the apical margin with small, close punctures; lateral areas of second tergite with moderate, usually distinct but occasionally confluent punctures, sparser towards the middle, the median area glabrous, almost impunctate; tergites 3–6 with small, distinct punctures; last tergite with a median, longitudinal, tumescent, glabrous area, not terminating in an elevation but rounded into the apical portion of the tergite; first sternite with a median, longitudinal carina on the anterior two-thirds, elevated slightly at the posterior terminus into a small, blunt tooth; second sternite with moderate, scattered punctures, occasionally confluent, sparser at the middle and posterior portions; all the sternites clothed with sparse, erect, pale pubescence and 2–6 each with a thin, apical fringe of pale pubescence; sternites 3–6 with small close punctures posteriorly and laterally; sternite 6 without lateral tubercles; posterolateral tubercles of sternite 7 small and inconspicuous; hypopygium with a pair of lateral, elevated ridges on the anterior two-thirds, distinctly converging towards the rear and each terminating in a distinct tubercle; interspace between the lateral ridges with small, close punctures.

Wings subfuscous, except cell M hyaline; cell 2nd $R_1 + R_2$ subtruncate at the apex, equal in length to cell R + 1st R_1; cell R_5 receiving vein M_{3+4} slightly beyond the middle; cell R_4 present, but less distinct than R_5 and receiving vein M_2 about two-thirds the distance from base to apex.

Legs entirely black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Kagi, Formosa, August, 1907 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—Male, Taihanroku, August, 1908 (H. Sauter); male, Taihorin, June, 1911 (H. Sauter); male, Formosa, December, 1913 (F. Muir).

This species differs from *denotata*, and *suspiciosa* subsp. *discolor* in the form of the clypeus and hypopygium, in having the abdomen more ferruginous, and the general puncturation somewhat less coarse.

Timulla (Trogaspidia) suspiciosa subsp. **discolor** n. subsp.

1913. *Mutilla analis* Zavattari, Arch. f. Naturg., Vol. 79 (3): 41, male (in part) (nec Lepeletier).

Male.—Head, thorax, abdominal segments one, six and last, and legs, black; abdominal segments 2–5 entirely ferruginous; median area of clypeus glabrous, impunctate with a median, low, longitudinal ridge; ocelli small; scutellum gibbose; hypopygium with a pair of lateral, longitudinal ridges on the anterior half, the ridges widely separate, near the lateral margins and only slightly convergent. Length, 15 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence, the lateral areas of clypeus, and the front with rather dense, appressed, pale pubescence, and the genae with sparse, appressed, pale pubescence in addition to the erect pubescence; mandibles tinged with ferruginous subapically, rather broad apically, bluntly edentate, and with a small tooth within near the apex, deeply excised beneath near the base; median area of clypeus large, hexagonal, glabrous, impunctate, almost flat except a median, longitudinal, low ridge extending from the posterior margin anteriorly to a submarginal, punctate, impressed line; scape bicarinate beneath, clothed with sparse, pale pubescence; first and second segments of flagellum approximately equal in length; antennal scrobes distinctly carinate above; front with moderate, dense, confluent punctures; vertex with moderate, separated and close, occasionally confluent punctures; genae with moderate, close, more or less confluent punctures; relative widths of head and thorax including the tegulae, 5.1–6.5.

Thorax entirely black, clothed throughout with sparse, erect, pale pubescence, except the mesonotum and anterior half of scutellum with sparse, erect and recumbent black pubescence, and the pronotum posteriorly also with dense, appressed, pale pubescence, as well as the dorsum of propodeum and mesopleura medially with thick, pale pubescence; pronotum with moderately large, dense, deep, confluent punctures; mesonotum with moderately large, close, confluent punctures, the parapsidal furrows deep, and with a median, longitudinal, slightly raised, glabrous line; scutellum strongly gibbose, with a broad, median, longitudinal, glabrous line on the anterior half, terminating at the apex of the elevated area; dorsum of propodeum, and the posterior face distinctly reticulate, the dorsum with a median, subtriangular enclosed area, about twice as long as wide at the base, the sides slightly sinuate, and the apex of the triangle rounded; propleurae transversely striatopunctate, the striae not reaching the apical margin; mesopleurae with large, shallow, confluent punctures, becoming obsolete at the anterior and posterior margins, the whole surface of the mesopleurae also micropunctate; metapleurae micropunctate and micropubescent, except ventrally with moderate, close punctures; sides of propodeum shallowly reticulate, the reticulations becoming obsolete anteriorly; tegulae black, glabrous throughout, impunctate except the anterior and inner margins punctate and black pubescent, and the posterior inner margin narrowly, densely pale pubescent.

Abdomen ferruginous, except the first, sixth and last segments black; tergites 1–5 with sparse, erect, pale golden pubescence, and each with a thin, apical fringe of pale golden pubescence; sixth and last tergites clothed with black pubescence; first tergite with moderate, separated punctures, except at the apical margin with small, close punctures; second tergite laterally with moderate distinct punctures, the latter becoming sparse towards the middle, thus the tergite glabrous, almost impunctate medially; tergites 3–6 with small, separated punctures; last tergite with a median, longitudinal, glabrous, tumescent area, not terminating in an elevation, but rounded into the apical portion of the tergite; first sternite with a median, longitudinal carina, slightly elevated at its posterior terminus to form a small, blunt tooth; second sternite with moderately large, close punctures laterally, and with small, close punctures at the apical margin; sternites 3–6 with moderately small punctures, sparse medially, close and somewhat confluent laterally and posteriorly; sixth sternite without lateral tubercles, seventh sternite with the posterolateral tubercles almost obsolete; hypopygium with a pair of lateral ridges on the anterior half, the ridges very widely separate, close to the lateral margins, only slightly converging posteriorly, and terminating in prominent tubercles.

Wings subfuscous, except cell M almost hyaline; cell 2nd $R_1 + R_2$ subtruncate at the apex, distinctly longer than cell R + 1st R_1; cell R_5 receiving vein M_{3+4} slightly less than two-thirds the distance from base to apex; cell R_4 present but less distinct than R_5, hexagonal, receiving vein M_2 at two-thirds the distance from base to apex.

Legs entirely black, sparsely clothed with pale pubescence; calcaria pale.

Holotype.—Male, Taihorinsho, Formosa, September, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Superficially this looks very much like ***denotata*** and the clypeus is very similar in form to that species. The hypopygium, however, is very different; in ***denotata*** the elevated ridges are strongly convergent, longer, and relatively near the middle, so that the space between is small, while in the specimen described above the ridges are very close to the lateral margins, shorter and only slightly convergent, with a large area of the sternite between them; the form of the clypeus and the pygidium is like that in ***suspiciosa*** Smith, the type of which I have examined. The Formosa specimen differs from ***suspiciosa*** only in having the abdomen more ferruginous. I therefore consider the Formosa form as a subspecies of ***suspiciosa*** differing in abdominal color as indicated in the key.

Timulla (Trogaspidia) rhea n. sp.

1913. *Mutilla gribodoi* Zavattari, Arch. f. Naturg., Vol. 79 (3): 42, male (nec Magretti).

Male.—Head, thorax and legs entirely black, abdomen black, except the second and third segments ferruginous; mandibles strongly excised beneath; clypeus with a high, prominent, median, longitudinal carina; scutellum gibbose; last tergite with a broad, median, tumescent, glabrous, impunctate area, rounded off posteriorly, not terminating in a tubercle; hypopygium with strong lateral ridges. Length, 18.5 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence, the front also with thick, recumbent, pale pubescence medially on the anterior half, and the genae with sparse, short, appressed, pale pubescence; mandibles deeply emarginate beneath and with a strong tooth near the base, edentate at the apex and with a small tooth within near the apex; clypeus with a strongly elevated, prominent, median, longitudinal carina extending from the posterior margin anteriorly to a transverse, submarginal, punctate, impressed line; scape distinctly bicarinate beneath, clothed with sparse, pale pubescence, first segment of flagellum equal in length, or very slightly longer than the second; front, vertex and genae with dense, confluent punctures, moderately large and deep on the front, shallow on the vertex, moderate on the genae, i. e., the punctures on the genae neither as large nor as deep as on the front; ocelli large, the distance between the eye margins and the lateral ocelli equal to about twice the greatest diameter of the latter; relative widths of head and thorax including the tegulae, 6.5–8.0.

Thorax entirely black, clothed throughout with sparse, erect, pale pubescence, except the mesonotum and anterior half of scutellum with sparse, recumbent and erect, black pubescence, the pronotum posteriorly and the mesopleurae medially also with dense, appressed, pale pubescence; pronotum, mesonotum and scutellum with large, dense, deep, confluent punctures; parapsidal furrows distinct and deep on the posterior two-thirds of mesonotum, the latter also with a median, longitudinal, glabrous, raised line; scutellum gibbose, with a broad, median, longitudinal, glabrous line on the anterior half terminating at the apex of the elevation; dorsum of propodeum and posterior face broadly, deeply reticulate, the one rounded into the other; dorsum of propodeum with a median enclosed space slightly more than twice as long as broad at the base, the anterior third about twice as wide as the posterior two-thirds; propleurae transversely striatopunctate, the striae not extending to the posterior margin; mesopleurae with large, confluent punctures, deep medially, shallow and smaller posteriorly and becoming entirely obsolete anteriorly, the anterior fifth micropunctate; metapleurae micropunctate except ventrally with moderate, shallow, close punctures; sides of propodeum reticulate, the reticulations becoming shallow and almost obsolete anteriorly; tegulae glabrous, impunctate, except the anterior and inner margins punctate and black pubescent.

Abdomen black, except the broad posterior margin of the first tergite, and the second and third segments entirely ferruginous, clothed

throughout with sparse, erect, pale pubescence, except the last two tergites with black pubescence, and the last two sternites with fuscous to black pubescence; first tergite with large, shallow, close punctures except the apical margin narrowly with small, close punctures; second tergite laterally with moderate, close punctures, medially glabrous, impunctate, posteriorly with small, very sparse punctures; tergites 3–6 with moderately small, distinct, well-separated punctures, a narrow area along the mid-line of each practically impunctate; last tergite with moderately small, dense punctures laterally, and with a median, longitudinal, broad, glabrous, tumescent area, rounded off posteriorly, not terminating in a tubercle or carina; first sternite with a prominent, median, longitudinal carina on the anterior half, the carina somewhat higher at its anterior and posterior termini; second sternite with large, shallow punctures, close laterally, sparse medially; sternites 3–6 with small, distinct, close punctures laterally and posteriorly; sixth sternite without lateral tubercles; seventh sternite with a pair of low, elongate tubercles near the lateral margin; hypopygium with a pair of strongly elevated, converging lateral ridges, the tips of the latter approximate, the distance between the tips equal to about half the length of the ridges; interspace between the ridges with small, dense punctures.

Wings fuscous, except cell M subhyaline; cell 2nd $R_1 + R_2$ truncate at the apex, distinctly longer than cell R + 1st R_1; cell R_5 receiving vein M_{3+4} at about three-fifths the distance from base to apex; cell R_4 present but less distinct than R_5 and receiving vein M_2 about three-fifths the distance from base to apex.

Legs black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Hoozan, Formosa, October, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—Two males, Hoozan, September, 1910 (H. Sauter); male, Kosempo, July, 1911 (H. Sauter); male, Kankau (Koshun), April, 1912 (H. Sauter); male, Kankau (Koshun), May, 1912 (H. Sauter); two males, Taihorin, March, 1910 (H. Sauter); male, Taihorin, May 2, 1909 (H. Sauter); three males, Taihorin, June, 1910 (H. Sauter); male, Taihorin, August 7, 1911 (H. Sauter); male, Taihorin, September, 1910 (H. Sauter); three males, Taihorin, October, 1910 (H. Sauter); three males, Taihorinsho, September, 1910 (H. Sauter); three males, Taihorinsho, October, 1909 (H. Sauter); male, Taihorinsho, November, 1910 (H. Sauter); in Zoologisches Museum der Universität, Berlin, Deutsches Entomologisches Institut, Berlin-Dahlem, Zoological Institute, University of Torino, Italy, collection of Dr. H. Hedicke, Berlin, and University of Minnesota, U. S. A.

Zavattari himself expressed a doubt as to the identity of this Formosa species with *gribodoi* Magretti. I have examined

the type of the latter at the Museo Civico Historia Naturale at Genoa and find it very different; in *gribodoi* the scutellum is not gibbose but evenly convex, the hypopygium is simple, without lateral ridges, and the formation of the clypeus is different. This species may have affinities with *analis* Lep., but I have not been able to determine that point by comparing specimens of the two species.

Timulla (Trogaspidia) rapa (Zavattari).

1913. *Mutilla rapa* Zavattari, Arch. f. Naturg., Vol. 79 (3): 36, male.

Lectotype.—Male, Taihorin, Formosa, October, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Timulla (Trogaspidia) orientalis subsp. **taiwanensis** n. subsp.

1913. *Mutilla dimidiata* Zavattari, Arch. f. Naturg., Vol. 79 (3): 42, male, (nec Lepeletier).

1913. *Mutilla gribodoi* Zavattari, Arch. f. Naturg., Vol. 79 (3): 42, male (in part).

Male.—Head, thorax, last three abdominal segments, and legs, black, the first four abdominal segments, ferruginous; mandibles broad at the apex, tridentate; clypeus depressed below the mandibles, the median tubercle at the posterior margin small, inconspicuous; first segment of flagellum about half the length of the second; scutellum evenly convex; hypopygium simple, without lateral elevated ridges. Length, 10.5 mm.

Head entirely black, clothed throughout with sparse, erect, pale pubescence, the front also with thick recumbent, pale pubescence; mandibles deeply emarginate beneath and with a strong tooth near the base; apices of the mandibles broad, tridentate, a dorsal carina extending from the base to the innermost tooth; clypeus depressed below the carinate margin of the mandibles, the surface micropunctate and finely pubescent, with a small, median, acute tubercle at the posterior margin; scape obscurely bicarinate beneath; first segment of flagellum about half the length of the second; antennal scrobes weakly carinate above; anterior half of front with a median, longitudinal, raised line; front with moderate, shallow, confluent punctures, vertex with moderate, shallow, sparse punctures, and the genae with moderate shallow, close punctures; ocellar and median postocellar area elevated; a very small, glabrous tubercle posterolaterad of each lateral ocellus at a distance equal to the diameter of the latter; ocelli small, the distance between the eye margins and the lateral ocelli equal to about four times the diameter of the latter; relative widths of head and thorax including the tegulae, 3.6–4.75.

Thorax entirely black, clothed throughout with sparse, erect, pale pubescence, except the mesonotum and anterior half of scutellum clothed with sparse, recumbent, black pubescence, and the pronotum, and mesopleurae medially, also with recumbent, pale pubescence;

pronotum, mesonotum and scutellum with moderate, dense, deep, confluent punctures, the scutellum evenly convex throughout and with the puncturation deeper and more confluent than on the pro- and mesonotum; parapsidal furrows complete from base to apex of mesonotum; dorsum of propodeum and posterior face rounded into one another, distinctly reticulate, the dorsum short and with a median enclosed space, the latter about one and one-half times as long as broad at the base, the posterior three-fifths slightly narrower than the anterior two-fifths; propleura transversely, shallowly, striatopunctate; mesopleurae with moderate, dense, confluent punctures, the latter becoming shallow and separated anteriorly, the ventral and dorsal elevated areas separated by a transverse, foveate furrow; mesosternum with a pair of distinct, anterolateral tubercles; metapleurae micropunctate except ventrally with large, close punctures; sides of propodeum distinctly reticulate except anteriorly the reticulations becoming shallow and obscure; tegulae exceeding the posterior margin of mesonotum by one-fourth their length, glabrous, impunctate except the broad, anterior margin, and anterior fourth of the inner half with small, distinct punctures and sparse, black pubescence.

Abdomen ferruginous except the last three segments black, the tergites clothed with sparse, pale golden pubescence except the last two tergites with black pubescence, tergites 2–4 each with a distinct apical fringe of golden pubescence, the sternites clothed with sparse, pale pubescence throughout; first tergite with moderately large, shallow, scattered punctures except the posterior margin with small, close punctures; second tergite with moderate, distinct punctures, close laterally, the median area almost impunctate; tergites 3–5 with small, distinct punctures; last tergite with small, close punctures; first sternite with a low, median, longitudinal carina on the anterior two-thirds; second sternite with moderate, close punctures; sternites 2–6 with small, close punctures posteriorly; hypopygium flat, simple, without lateral ridges, with moderately small, close punctures.

Wings subfuscous throughout; cell 2nd R_1 + R_2 subtruncate, slightly longer than cell R + 1st R_1; distance between vein M and the stigma equal to the length of the latter, vein r arising at the middle of the stigma; cell R_5 receiving vein M_{3+4} at two-thirds the distance from base to apex; cell R_4 present but much less distinct than R_5 and receiving vein M_2 at two-thirds the distance from base to apex.

Legs black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Taihanroku, Formosa, August 3–10, 1908 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—Male, Kosempo, June, 1911 (H. Sauter); male, Shis, May, 1911 (H. Sauter); in Zoological Institute, University of Torino, Italy, and University of Minnesota, U. S. A.

Closely related to *orientalis* but differs principally in the smaller clypeal tubercle and in the coloration of the abdomen. The paratypes are both 18 mm. in length, but are otherwise

the same as the holotype. See Mickel, Ann. Ent. Soc. Amer., 26: 377 for redescription of *orientalis* (=*dimidiata* Lep., nec Latreille) and remarks regarding the identity of that species.

Timulla (Trogaspidia) gutrunae (Zavattari).

1913. *Mutilla gutrunae* Zavattari, Arch. f. Naturg., Vol. 79 (3): 34, male.

Lectotype.—Male, Taihorin, July, 1911 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Timulla (Trogaspidia) friekae (Zavattari).

1913. *Mutilla friekae* Zavattari, Arch. f. Naturg., Vol. 79 (3): 35, male.

Lectotype.—Male, Formosa (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Timulla (Trogaspidia) friekae subsp. **discrepans** n. subsp.

1913. *Mutilla discreta* Zavattari, Arch. f. Naturg., Vol. 79 (3): 35, male (nec Cameron).

Male.—Entirely black, the abdominal tergites 1–4 all pale pubescent at the apical margin; first segment of flagellum distinctly shorter than the second; mandibles not emarginate nor toothed beneath; scutellum evenly convex throughout, not elevated; tegulae blackish. Length, 9 mm.

Head entirely black, clothed with sparse, erect and recumbent, pale pubescence, distinctly thicker on the front than on the vertex and genae; mandibles bidentate at the apex, subapically tinged with ferruginous; median area of clypeus slightly elevated, flat, glabrous, unsculptured; scape with a single sharp carina beneath; first segment of flagellum seven-tenths the length of the second; antennal scrobes indistinctly carinate above; front, vertex and genae with moderate, shallow punctures, close and confluent on the front, separated on the vertex, close but not confluent on the genae; relative widths of head and thorax including the tegulae, 3.2–3.7.

Thorax entirely black; clothed throughout with sparse, pale pubescence, the mesonotum also with sparse, recumbent, dark fuscous pubescence; pronotum and mesonotum with moderate, more or less confluent punctures; scutellum evenly, slightly convex, with moderate, dense, confluent punctures; dorsum and posterior face of propodeum reticulate, the dorsum with a median, enclosed space about twice as long as broad at the base, the anterior third wider than the posterior two-thirds; propleurae micropunctate; mesopleurae with moderate, confluent punctures except at the anterior margin micropunctate; metapleurae and anterior half of sides of propodeum micropunctate and micropubescent except the metapleurae ventrally with moderate, shallow punctures; posterior half of sides of propodeum shallowly reticulate; tegulae blackish on the basal half, blackish brown on the apical half, the latter somewhat concave, glabrous throughout, and with small scattered punctures anteriorly.

Abdomen entirely black; first tergite with moderate, separated punctures, the latter becoming small and close at the apical margin, clothed with sparse, erect, pale pubescence, and with a thin, apical fringe of pale pubescence; second tergite with moderate, well-separated punctures, clothed with sparse, erect and recumbent, pale pubescence and with an apical fringe of pale pubescence; third and fourth tergites with moderately small, separated punctures, clothed with sparse, erect, pale pubescence; fifth, sixth and pygidial tergites with moderately small, distinct punctures, clothed with sparse, erect, black pubescence; first sternite with a median, longitudinal carina on the anterior three-fourths; second sternite with moderate, distinct punctures, clothed with scattered, erect, pale pubescence, and with a thin apical fringe of pale pubescence; sternites 3–6 with small, close punctures, and with a thin, apical fringe of pale pubescence; hypopygium with small, close punctures and sparse, erect, pale pubescence.

Wings subfuscous; cell 2nd $R_1 + R_2$ subtruncate, almost acuminate at the apex; cell R + 1st R_1 about six-sevenths the length of 2nd $R_1 + R_2$; cell R_5 receiving vein M_{3+4} slightly beyond the middle; cell R_4 much less distinct than R_5 and receiving vein M_2 distinctly beyond the middle.

Legs entirely black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Male, Taihorinsho, Formosa, September, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratypes.—Two males, Taihorinsho, September, 1910 (H. Sauter); five males, Kankau (Koshun), April, 1912 (H. Sauter); five males, Kankau (Koshun), May, 1912 (H. Sauter); male, Kankau (Koshun), June, 1912 (H. Sauter); male, Taihorin, October, 1910 (H. Sauter); in Zoologisches Museum der Universität, Berlin; Deutsches Entomologisches Institut, Berlin-Dahlem; Dr. H. Hedicke collection, Berlin; Zoological Institute, University of Torino, Italy, and University of Minnesota, U. S. A.

This is certainly not the same as *discreta* Cameron described from India. It is very close to *friekae* Zavattari, but differs in having pale pubescence on the fourth tergite, and the tegulae blackish rather than testaceous. The form of the mandibles, clypeus and general puncturation is the same in both.

Timulla (Trogaspidia) repraesentoides n. sp.

1913. *Mutilla repraesentans* Zavattari, Arch. f. Naturg., Vol. 79 (3): 29, female (nec Smith).

Female.—Head, abdomen and legs black, the thorax ferruginous; second tergite with a pair of large, subcircular, anterior spots separated by approximately one-third their diameter, the third and fourth tergites each with a broad band, narrowly interrupted medially with black, all

of dense, appressed, pale golden pubescence; pygidium delicately irregularly rugose anteriorly, the posterior two-thirds glabrous, unsculptured. Length, 6 mm.

Head entirely black, except the mandibles medially and the antennal tubercles tinged with ferruginous; mandibles slender, edentate at the apex and with a small tooth within; clypeus elevated posteriorly, the elevated margin arcuate and with a median tubercle immediately posterior to the elevated margin; scape clothed with sparse, pale pubescence; first segment of flagellum longer than the second but shorter than the second and third united; antennal scrobes distinctly carinate above; front and vertex with moderate, close, confluent punctures, clothed with sparse, recumbent and erect, pale pubescence, except the posterior part of vertex also with sparse, appressed, pale pubescence; genae with the moderate punctures somewhat more separated than on the front and vertex, clothed with sparse, erect and appressed, pale pubescence; relative widths of head and thorax, 2.7–2.3.

Thorax entirely ferruginous; dorsum with sparse, erect and recumbent, pale pubescence, the posterior face of propodeum with only erect, pale pubescence; dorsum with large, dense, deep, confluent punctures, becoming reticulate on the posterior face of propodeum; thorax slightly narrower posteriorly than anteriorly, the sides approximately parallel, except the mesothoracic area slightly narrower than either the pronotal, or the metathoracic and propodeal area; humeral angles somewhat rounded, not distinctly angulate; scutellar scale well-developed; lateral margins of posterior face of propodeum denticulate; pleural areas micropunctate and micropubescent, except the sides of propodeum with shallow, indistinct reticulations posteriorly.

Abdomen black; first tergite with small to fine punctures, clothed with sparse, erect, pale pubescence, the apical fringe black; second tergite with a pair of large, subcircular, anterior spots of dense, appressed, pale golden pubescence, the spots extending anteriorly almost to the anterior margin and posteriorly beyond the transverse median line, separated by approximately one-third of their diameter, the remainder of the tergite clothed with appressed, black pubescence except the anterolateral areas with sparse, erect, pale hairs, and the lateral margins with sparse, appressed and erect, pale pubescence, the apical fringe black; small, separated punctures visible through the pale pubescence of the spots; third and fourth tergites each with a broad band of dense, appressed, pale golden pubescence covering practically the entire tergite, but each interrupted medially by a narrow line of black pubescence; fifth tergite entirely black pubescent; pygidial area delicately irregularly rugose on the anterior third, the posterior two-thirds glabrous, unsculptured; first sternite with a median, longitudinal carina on the anterior two-thirds; second sternite with small, well-separated punctures, scattered, erect, pale pubescence, and a thin, apical fringe of pale pubescence; sternites 3–5 with small, close punctures at the apical margin and each with a thin, apical fringe of pale pubescence; hypopygium with small, dense punctures and sparse, erect, pale pubescence.

Legs black, except the coxae tinged with ferruginous; clothed with sparse, erect and recumbent pale pubescence; calcaria pale.

Holotype.—Female, Hoozan, Formosa, February, 1910 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Paratypes.—Female, Hoozan, January, 1910 (H. Sauter); female, Hoozan, March, 1910 (H. Sauter); female, Taihorinsho, October, 1909 (H. Sauter); female, Taihorin, April, 1910 (H. Sauter); nine females, Taihorin, June, 1911 (H. Sauter); female, Taihorin, October, 1910 (H. Sauter); in Deutsches Entomologisches Institut, Berlin-Dahlem, Zoologisches Museum der Universität, Berlin; Dr. H. Hedicke collection, Berlin; Zoological Institute, University of Torino, Italy, and University of Minnesota, U. S. A.

The species determined by Zavattari as *repraesentans* Smith while very similar to Smith's species superficially is really quite different. I have examined the type of Smith's *repraesentans* which came from India, and have before me a specimen from Rangoon, Burma, compared with the type by Dr. Hugh Scott and Mr. Robert B. Benson, of the British Museum of Natural History. The most obvious and important difference is in the sculpture of the pygidium which in *repraesentans* Smith is distinctly, longitudinally striated; the pale spots of the second tergite are also much smaller in *repraesentans* Smith, the distance between them being four-fifths of their diameter, and the coxae are entirely ferruginous. The paratypes vary in length from 6 to 8 mm.

Timulla (Trogaspidia) logei (Zavattari).

1913. *Mutilla logei* Zavattari, Arch. f. Naturg., Vol. 79 (3): 30, female.

Lectotype.—Female, Hoozan, Formosa, February, 1910 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Timulla (Trogaspidia) pfafneri (Zavattari).

1913. *Mutilla pfafneri* Zavattari, Arch. f. Naturg., Vol. 79 (3): 30, female.

Lectotype.—Female, Taihorin, Formosa, March, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Timulla (Trogaspidia) minae (Zavattari).

1913. *Mutilla minae* Zavattari, Arch. f. Naturg., Vol. 79 (3): 29, female.

Lectotype.—Female, Taihorinsho, Formosa, October, 1909 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Timulla (Trogaspidia) repraesentans subsp. **taihorina** n. subsp.

1913. *Mutilla subintrans* Zavattari, Arch. f. Naturg., Vol. 79 (3): 29, female (nec Sichel and Radoskowski).

Female.—Head, abdomen and legs black, the thorax ferruginous; second tergite with a pair of subcircular, anterior, lateral spots, of dense, appressed, pale pubescence, separated by about four-fifths their diameter; third tergite with a broad band of dense, appressed, pale pubescence, not interrupted medially, the fourth tergite with a similar band of pale pubescence, but distinctly interrupted medially; pygidial area longitudinally striated. Length, 9 mm.

Head entirely black, clothed with sparse, erect and semirecumbent, pale pubescence, except the genae and posterior part of vertex also with sparse, appressed, pale pubescence; mandibles slender, edentate at the apex and with a small tooth within; clypeus elevated posteriorly with the elevated margin arcuate; scape clothed with sparse, pale pubescence; first segment of flagellum longer than the second and almost as long as the second and third united; antennal scrobes distinctly carinate above; front and vertex with moderate, dense, confluent punctures, the genae with moderate, close confluent punctures, somewhat less coarsely sculptured than the front and vertex; relative widths of head and thorax, 3.8–3.4.

Thorax entirely ferruginous, the dorsum clothed with sparse, erect and recumbent, pale pubescence, the posterior face of propodeum with only sparse, erect, pale pubescence; mesothoracic area distinctly constricted, the metathoracic and propodeal area slightly wider than the pronotal; relative widths of pronotal, mesothoracic and propodeal areas, 3.4–3.1–3.5; dorsum with large, dense, confluent punctures becoming longitudinally furrowed on the posterior face of propodeum; humeral angles subangulate; scutellar scale well-developed; lateral margins of posterior face of propodeum denticulate; pleural areas micropunctate and micropubescent, except the sides of propodeum with shallow, indistinct moderate punctures.

Abdomen black; first tergite with intermixed moderate and fine punctures, clothed with sparse, erect, pale pubescence, the apical fringe pale fuscous; second tergite with appressed, black pubescence, except the lateral areas with sparse, erect, pale hairs, the posterior half of the lateral margins with dense, appressed, pale pubescence, and a pair of subcircular, anterior spots of dense, appressed, pale pubescence, separated by about four-fifths of their diameter; second tergite with intermixed, moderate and fine, separated punctures, the moderate punctures visible through the pubescence of the pale spots; apical fringe of second tergite black; third tergite with a broad band of dense, appressed, pale pubescence, not interrupted medially; fourth tergite with a broad band of similar, pale pubescence, but distinctly interrupted medially; fifth tergite black pubescent throughout except sparse, erect, pale hairs laterally; pygidial area distinctly, longitudinally striate, the striae not reaching the posterior margin; first sternite with a median, longitudinal carina on the anterior two-thirds, the carina

elevated medially to form a distinct blunt tooth; second sternite with moderate, scattered punctures throughout, the latter becoming small and close at the posterior margin, clothed with scattered, erect, pale pubescence, except at the apical margin with a narrow band of dense, appressed, pale pubescence and a thin apical fringe of pale hairs; sternites 3–5 with small, close punctures at the apical margin, and each with a thin apical fringe of pale hairs; hypopygium with small, dense punctures and sparse, erect, pale pubescence.

Legs entirely black, clothed with sparse, appressed and erect, pale pubescence; calcaria pale.

Holotype.—Female, Kankau (Koshun), Formosa, April, 1912 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Paratypes.—Female, Hoozan, May, 1910 (H. Sauter); female, Hoozan, October, 1910 (H. Sauter); female, Taihorin, January, 1910 (H. Sauter); female, Taihorin, March, 1910 (H. Sauter); two females, Taihorin, June, 1910 (H. Sauter); four females, Taihorin, June, 1911 (H. Sauter); three females, Taihorin, July, 1911 (H. Sauter); female, Taihorin, October, 1910 (H. Sauter); female, Kosempo, May, 1911 (H. Sauter); female, Tainan, July, 1911 (H. Sauter); female, Tainan, August, 1911 (H. Sauter); two females, Taihorinsho, October, 1909 (H. Sauter); female, Taihorinsho, November, 1909 (H. Sauter); in Deutsches Entomologisches Institut, Berlin-Dahlem, Dr. H. Hedicke collection, Berlin; Zoological Institute, University of Torino, Italy, and University of Minnesota, U. S. A.

This species is very closely related to *repraesentans* Smith, differing only in its larger average size and the uninterrupted pale pubescent band of the third tergite. The pygidial area is sculptured the same in the Formosa form as in Smith's species. I therefore consider it as a subspecies of *repraesentans* Smith.

Sichel and Radoskowski list two localities for their species *subintrans*, Ceylon and Timor. I have not been able to locate the Ceylon specimen. The Timor specimen is in the Zoologisches Museum der Universität, Berlin. It belongs with the *philippinensis* Smith group of subspecies having the pygidium irregularly rugose. The subspecies *taihorina* is certainly not the same as *subintrans* Sich. and Rad. from Timor and the possibility of it being the same as *subintrans* Sich. and Rad. from Ceylon is exceedingly remote.

Genus **Smicromyrme** Thomson.

KEY TO THE MALES OF SMICROMYRME.

1. Thorax, except pleural areas and usually the propodeum, ferruginous; abdomen steel-blue or black 2
   Thorax entirely black; abdomen black and ferruginous, or entirely black.... 5
2. Abdominal tergites 1–3, each with a distinct apical fringe of pale golden pubescence, but without appressed, pubescent bands 3
   Abdominal tergites 1–3 with an apical band of dense, appressed pubescence, that of the second broad; tegulae twice as long as broad; dorsal third of mesopleurae ferruginous; propodeum and legs entirely black; wings subhyaline. (Page 417) ..... **drola**
3. Thorax entirely ferruginous, except the ventral half of mesopleurae blackish. (Page 416) ..... **strandi**
   At least the propodeum entirely black 4
4. First segment of flagellum equal to one-third the length of the second; scutellum and mesopleurae entirely black. (Page 417) ..... **serpa**
   First segment of flagellum equal to one-half the length of the second; scutellum and dorsal half of mesopleurae ferruginous. (Page 417)..... **naja**
5. Abdomen entirely black 6
   At least the second abdominal segment ferruginous 7
6. Pronotum clothed with dense, appressed, pale golden pubescence; abdomen distinctly black. (Page 417) ..... **hageni**
   Pronotum clothed only with sparse, pale fuscous, erect pubescence; abdomen with a distinct, metallic blue tinge. (Page 417)..... **guntheri**
7. Tegulae almost entirely rufotestaceous; third abdominal segment ferruginous. (Page 417) ..... **norna**
   Tegulae almost entirely or entirely blackish; third abdominal segment black. (Page 417) ..... **drupa**

KEY TO THE FEMALES OF SMICROMYRME.

1. Second tergite with an apical band of pale pubescence, and sometimes with a single, median, anterior spot of pale pubescence 2
   Second tergite with three spots of pale pubescence 4
2. Second tergite with an anterior, median spot of pale pubescence; abdomen black 3
   Second tergite without an anterior, median, pale pubescent spot, with only an apical pale pubescent band; abdomen dark metallic blue. (Page 417) ..... **thalia**
3. Fourth tergite entirely black pubescent; second tergite with small, dense, confluent punctures throughout. (Page 420) ..... **wotani**
   Fourth tergite clothed with pale pubescence, except the apical fringe medially, black; second tergite with small, distinct, separated punctures throughout. (Page 420) ..... **thia**
4. Pale spots of second tergite transversely aligned, the median spot almost twice as large as the lateral ones; front glabrous, with moderate, slightly separated punctures; first abdominal segment blackish. (Page 421) ..... **alberici**
   Pale spots of second tergite not transversely aligned, the median one anterior and subequal in size to the lateral ones; front with moderate, dense, confluent punctures; first abdominal segment ferruginous. (Page 421) ..... **triguttata**

Smicromyrme strandi (Zavattari).

1913. *Mutilla strandi* Zavattari, Arch. f. Naturg., Vol. 79 (3): 36, male.

Lectotype.—Male, Taihorin, Formosa, October, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Smicromyrme serpa (Zavattari).

1913. *Mutilla serpa* Zavattari, Arch. f. Naturg., Vol. 79 (3): 39, male.

Lectotype.—Male, Taihorinsho, Formosa, August, 1909 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Smicromyrme naja (Zavattari).

1913. *Mutilla naja* Zavattari, Arch. f. Naturg., Vol. 79 (3): 38, male.

Lectotype.—Male, Taihorin, Formosa, August 7, 1911 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Smicromyrme drola (Zavattari).

1913. *Mutilla drola* Zavattari, Arch. f. Naturg., Vol. 79 (3): 37, male.

Lectotype.—Male, Taihorin, Formosa, November, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Smicromyrme hageni (Zavattari).

1913. *Mutilla hageni* Zavattari, Arch. f. Naturg., Vol. 79 (3): 32, male.

Lectotype.—Male, Kankau, Formosa, April 7, 1912 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Smicromyrme guntheri (Zavattari).

1913. *Mutilla guntheri* Zavattari, Arch. f. Naturg., Vol. 79 (3): 33, male.

Lectotype.—Male, Taihorinsho, Formosa, October, 1909 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Smicromyrme norna (Zavattari).

1913. *Mutilla norna* Zavattari, Arch. f. Naturg., Vol. 79 (3): 40, male.

Lectotype.—Male, Taihorin, Formosa, May, 1909, (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Smicromyrme drupa (Zavattari).

1913. *Mutilla drupa* Zavattari, Arch. f. Naturg., Vol. 79 (3): 41, male.

Lectotype.—Male, Kankau (Koshun), Formosa, April 7, 1912 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Smicromyrme thalia n. sp.

1913. *Promecilla calliope* Zavattari, Arch. f. Naturg., Vol. 79 (3): 23, female (nec Smith).

Female.—Head black, thorax entirely ferruginous, abdomen dark metallic blue; coxae, trochanters and proximal third of femora

ferruginous, the distal third of femora, tibiae and tarsi entirely, blackish; apical margin of second and third tergites with a transverse, complete band of dense, appressed, pale pubescence; scutellar scale present; pygidial area faintly margined laterally, glabrous, unsculptured. Length, 6 mm.

Head black, the front and vertex clothed with sparse, recumbent and erect, fuscous pubescence, the genae with sparse, mostly appressed, pale pubescence; proximal two-thirds of mandibles ferruginous, the distal third black, slender, edentate at the tip and with a small tooth within near the apex; clypeus elevated posteriorly into an arcuate carina extending from one side to the other immediately anterior to the antennal tubercles; antennal tubercles ferruginous; antennae black, except the flagellum beneath tinged with ferruginous beyond the first segment; first segment of flagellum about one and one-half times the length of the second; antennal scrobes distinctly carinate above; front and vertex with moderate, dense, confluent punctures, the genae with smaller, dense, confluent punctures; head feebly angulate between the genae and postgenae; relative widths of head and thorax, 2.2–2.1.

Thorax entirely ferruginous, elongate, narrowed anteriorly and posteriorly, widest at anterior spiracles, relative widths: at humeral angles, 1.8; at anterior spiracles, 2.1; and at scutellar scale, 1.8; dorsum of thorax with moderately large, dense, somewhat confluent punctures, becoming reticulate on the posterior face of propodeum, clothed with sparse, recumbent and erect, fuscous pubescence; scutellar scale present and distinct; humeral angles distinctly angulate; lateral margins of dorsum of thorax distinctly, narrowly emarginate at the anterior spiracles; sides of thorax very delicately sculptured, finely chagreened except the propleurae, and mesopleurae ventrally, with shallow, indistinct punctures.

Abdomen dark metallic blue, the apical margins of the second and third tergites with a distinct, transverse band of dense, appressed, pale pubescence; first tergite with small, close punctures, and sparse, erect, pale pubescence; second tergite with small, dense punctures, the latter becoming separated and sparse towards the lateral margins, clothed for the most part with sparse, recumbent and erect, blackish pubescence, except the apical band mentioned above, and the lateral fifths with sparse, erect, pale hairs, without any indication of pale pubescent spots anteriorly; tergites 3–5 with fine, close, shallow punctures, the third with a pale, transverse, pubescent band as mentioned above, the fourth and fifth with erect and recumbent, blackish pubescence, except each at the lateral margins with sparse, erect, pale hairs; pygidial area distinct, defined laterally by a feeble carina, glabrous, unsculptured; first sternite ferruginous, and with a median, longitudinal carina; second sternite with moderate, separated punctures and sparse, erect, pale hairs, as well as a thin, apical fringe of pale hairs; sternites 3–5 with fine, close punctures posteriorly, and each with a thin, apical fringe of pale hairs.

Coxae, trochanters and proximal third of femora ferruginous, remainder of legs blackish, clothed throughout with sparse, pale pubescence; calcaria pale.

Holotype.—Female, Taihorin, Formosa, August 7, 1911 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Paratype.—Female, Kankau (Koshun), Formosa, June, 1912 (H. Sauter), in collection of University of Minnesota, U. S. A.

I have been able to examine the type of *calliope* Smith described from Borneo, which is in the Saunder's collection at Oxford University, Oxford, England, and have before me a specimen from Borneo compared with Smith's type. The Formosa specimens differ from Smith's type in the heavier mandibles, shape of the thorax, absence of scutellar scale on the thorax, maculation of the second abdominal segment, and the more ferruginous legs. Although Smith's description of *calliope* does not mention a median, anterior, pale pubescent spot on the second abdominal tergite, an examination of the type shows that one is normally present but has been rubbed off in the type specimen, and specimens from Borneo agreeing in every other respect with the type, have this median, pale spot. Zavattari's Formosa specimens of *calliope* are entirely immaculate anteriorly and there is no indication of any pale spot whatever. Smith's type of *calliope* has the sides of the thorax approximately parallel in contrast to the condition described above, and in addition to the absence of the scutellar scale, has the femora of all the legs almost entirely ferruginous, as well as the tibiae of the front legs.

Zavattari suspected that the Formosa specimens were not the same as *calliope* Smith and therefore drew up a description of the specimen before him at the time, which should be consulted in connection with the above description of the same specimen. The paratype from Kankau is slightly smaller than the holotype, length, 5 mm., but is otherwise the same as the type.

This species may be the female of *naja* Zavattari. The latter is the only male of this genus from Formosa which has a metallic blue abdomen, and specimens are at hand from both Taihorin and Kankau.

I have also compared the Formosa specimens with *Promecilla regia* Smith, the genotype of the genus *Promecilla* and find that it should not be referred to that genus on account of the entirely different form of the thorax and second abdominal segments. The only character common to the two is the metallic blue color

of the abdomen which is not characteristic of *Promecilla* alone, but is characteristic of a number of species of *Smicromyrme* as well as *Squamulotilla*. The species is more correctly referable to *Smicromyrme*.

Smicromyrme wotani (Zavattari).

1913. *Mutilla wotani* Zavattari, Arch. f. Naturg., Vol. 79 (3): 27, female.

Lectotype.—Female, Tainan, Formosa, August, 1909 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Smicromyrme thia n. sp.

Female.—Head, abdomen and legs black, the thorax entirely ferruginous; scutellar scale present and distinct; second tergite with a median, elongate spot and a narrow, apical band, third tergite entirely, and fourth tergite entirely except the apical fringe medially, black, all with thick, appressed and sparse, erect, pale pubescence; pygidium distinctly longitudinally striate. Length, 5 mm.

Head entirely black, clothed throughout with sparse, erect, and recumbent, pale pubescence; mandibles except the tips ferruginous, edentate at the apex; antennal tubercles blackish; scape glabrous, with sparse, pale pubescence, antennal scrobes not carinate above; front and vertex with moderate, close, slightly confluent punctures, the genae with small, shallow, close punctures; relative widths of head and thorax, 2.5–1.9.

Thorax entirely ferruginous, clothed throughout with sparse, erect, pale pubescence; mesonotal area very slightly narrower than the pronotal and propodeal areas; dorsum with moderate, dense, confluent punctures becoming reticulate on the posterior face of propodeum; humeral angles rounded; scutellar scale present and well developed; mesonotal-propodeal suture well defined; lateral margins of posterior face of propodeum very slightly serrate but not denticulate; pleural areas including sides of propodeum, micropunctate.

Abdomen entirely black; first tergite with small, sparse punctures and sparse, erect, pale hairs; second tergite with small, distinct, separated punctures throughout, clothed with sparse, recumbent black pubescence, except laterally with sparse, erect, pale pubescence, and a median, elongate, anterior spot as well as a narrow, apical band of thick, appressed and sparse, erect, pale pubescence; tergites 3–5 with fine, separated punctures; third and fourth tergites clothed entirely with thick appressed and sparse, erect, pale pubescence except the fourth with the apical fringe black at the middle; fifth tergite entirely black pubescent except sparse, erect, pale pubescence at the lateral margins; pygidial area longitudinally striate, occupying almost all of the last tergite; first sternite with a median, longitudinal carina on the anterior two-thirds; second sternite with small, scattered punctures, sparse, erect pale pubescence, and a thin, apical fringe of pale pubescence;

sternites 3–5 with small, close punctures posteriorly and each with a thin, apical fringe of pale pubescence; hypopygium with small, close punctures, and sparse, erect, pale pubescence.

Coxae except the tips beneath, trochanters beneath, and femora tinged beneath, ferruginous, otherwise the legs black, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Female, Koroton, Formosa, September 7, 1907 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

Paratype.—Female, Anping, Formosa, July 11 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Somewhat similar in appearance to *wotani*, but easily recognized from that species by the puncturation of the second tergite, by the smaller, median, anterior, pubescent spot of second tergite, by the pale pubescence of the fourth tergite, and its smaller size. The paratype has the anterior portion of the second segment rubbed so that the anterior pale pubescent spot is not obvious and the fourth tergite is dark fuscous pubescent medially.

Smicromyrme alberici (Zavattari).

1913. *Mutilla alberici* Zavattari, Arch. f. Naturg., Vol. 79 (3): 31, female.

Lectotype.—Female, Tainan, Formosa, August, 1911 (H. Sauter), in Deutsches Entomologisches Institut, Berlin-Dahlem.

Smicromyrme triguttata n. sp.

1913. *Mutilla pandora* Zavattari, Arch. f. Naturg., Vol. 79 (3): 31, female (nec Smith).

Female.—Head, abdomen and legs black, the thorax, first abdominal segment and coxae, ferruginous; second abdominal tergite with three subcircular spots of dense, appressed, pale pubescence, and a narrow, apical band of similar pubescence; third tergite with a broad, complete band of dense, appressed, pale pubescence; pygidium finely, longitudinally striate. Length, 9 mm.

Head black, except the proximal half of mandibles ferruginous; scape and flagellum very dark mahogany red, almost black, except the flagellum tinged with ferruginous beneath; mandibles slender, edentate at the tips, apparently without a tooth within; clypeus elevated posteriorly forming a small tooth, between and immediately anterior to the antennal tubercles; antennal scrobes not carinate above; front, vertex and genae with moderate, dense, deep, confluent punctures, those on the genae somewhat smaller than on the front and vertex; front and vertex clothed with sparse, semirecumbent, inconspicuous, coppery pubescence, and sparse, erect, pale pubescence, the genae with sparse, semirecumbent and erect, pale pubescence; relative widths of head and thorax, 3.5–3.0.

Thorax entirely ferruginous; mesothoracic area narrowed, the thorax being most narrow at the propodeal tubercles; relative widths of thorax at humeral angles, anterior spiracles, propodeal spiracles and scutellar scale, 2.9–3.05–2.5–2.85; dorsum with large, dense, deep, confluent punctures becoming reticulate on the posterior face of propodeum, the dorsum clothed with sparse, recumbent, ferruginous pubescence, and sparse, erect, pale hairs; posterior face of propodeum with sparse, erect, pale hairs; humeral angles somewhat rounded; scutellar scale broad and well-developed; lateral margins of posterior face of propodeum serrate; pleural areas micropunctate and micropubescent, the sides of the propodeum also with moderate, shallow, very indistinct punctures.

Abdomen black, except the first segment entirely ferruginous; first tergite with sparse, erect, pale hairs, and a thin, apical fringe of pale pubescence; second tergite with black, recumbent pubescence, except the lateral fourths with very sparse, erect, pale pubescence, the posterior half of the lateral margins with dense, pale pubescence, the apical margin with a narrow band of dense, appressed, pale pubescence (the apical pubescent band about twice as broad at the middle as at the sides), and three subcircular spots of dense, appressed, pale pubescence (the two lateral spots on the transverse median line, the third placed medially and somewhat anterior to the lateral ones); median pubescent spot of second tergite slightly larger than the lateral ones, relative diameters, 1.2–1.0, the distance between the median spot and the lateral ones equal to the diameter of the latter; third tergite with a broad, complete band of dense, appressed, pale pubescence; third and fourth tergites entirely black pubescent except for a few, erect, pale hairs at the lateral margins; pygidial area covering most of the last tergite, finely, longitudinally striate, the striae reaching the apical margin; first sternite with a median, longitudinal carina on the anterior three-fourths, the carina straight when viewed laterally, not elevated into a tooth; second sternite with moderate, rather close punctures, sparse, erect, pale pubescence, and a thin, apical fringe of pale pubescence; tergites 3–5 with small, close punctures at the apical margin, and each with a thin, apical fringe of pale pubescence; hypopygium with small, close punctures and sparse, erect, pale hairs.

Legs blackish, except the coxae, trochanters, and femora beneath more or less, ferruginous, clothed with sparse, pale pubescence; calcaria pale.

Holotype.—Female, Taihorin, Formosa, October, 1910 (H. Sauter), in Zoologisches Museum der Universität, Berlin.

I have examined Smith's type of *pandora* and find the Formosa species does not agree with it. Smith's *pandora* came from Borneo; it has the scape, antennal tubercles and legs, entirely bright ferruginous, the thorax is almost parallel-sided and only very slightly constricted medially, the spots on the second tergite are much smaller, the distance between the median and the lateral spots being twice the diameter of the

latter, the median spot is narrow and elongate rather than subcircular, and the apical, pale pubescent band of the second tergite is interrupted medially with black. I have seen no other Oceanic species of *Smicromyrme* similar to this Formosa species.

LITERATURE CITED.

André, E. 1908. Description de quelques nouveaux Mutillides du Musée National de Hongrie. Ann. Hist. nat. Mus. Nat. Hung., 6: 375–383.

Bischoff, H. 1920. Monographie der Mutilliden Afrikas. Archiv. f. Naturg., 86 (Abt. A, Heft, 1–5): 1–830, Pl. 107.

Bradley, J. Chester, and **Bequaert, J.** 1923. Studies in African Mutillidae. Rev. Zool. Africaine, 12 (fasc. 3): 211–258.

1928. A Synopsis of the Mutillidae of the Belgian Congo. Bull. Amer. Mus. Nat. Hist., 58 (Art. 2): 63–122.

Mickel, Clarence E. 1933. A New Name for *Mutilla dimidiata* Lepeletier, with a redescription of the type specimen. Ann. Ent. Soc. Amer. 26: 377–380.

Zavattari, E. 1910. Catalogo delle Mutille del Museo Zoologico di Napoli. Ann. Mus. Zool. Univ. Napoli, n. s., 3 (9): 1–16.

1913. H. Sauter's Formosa-Ausbeute. Mutillidae. Arch. f. Naturg., 79 (Heft 3): 19–42.

ANIMAL LIFE AND SOCIAL GROWTH, by WARDEN CLYDE ALLEE. Pages i–xii and 1–159, with 11 figures. Published by Williams and Wilkins Company, Baltimore, Md. $1.00.

This is one of the small volumes of the Century of Progress Series which present the essential features of the fundamental sciences. They are sponsored by the National Research Council and the Century of Progress Exposition in Chicago. In general this volume takes up problems of aggregation as was done more in detail in the author's recent volume on "Animal Aggregations." However it is much more brief and contains more general ecology. The ten chapter heads are as follows: I, The Animal Community; II, Animal Habitats; III, Community Analysis; IV, Organization of Land Communities; V, Evolution of Animal Communities; VI, Unbalance in Nature; VII, Aggregations of Animals; VIII, Physiological Effects Produced by Aggregations; IX, Structural Effects Produced by Aggregations, and, X, The Higher Social Levels.

Being more condensed with fewer citations of examples the volume is more readable than Allee's "Animal Aggregations." It is written for those uneducated in technical biology, but gives us such a clear discussion of the problems of aggregation that it will be a feature of this branch of biological literature. It has been found to be very useful as "outside reading" for the students in our very large classes in "beginning zoology," giving them ecological concepts without the overload of ecological terminology.—C. H. K.

THE MEANING OF ANIMAL COLOUR AND ADORNMENT, BEING A NEW EXPLANATION OF COLOURS, ADORNMENTS AND COURTSHIPS OF ANIMALS, ETC., ETC., by MAJOR R. W. G. HINGSTON, pp. 1–411, with 40 text figures, 1933. Published by Edward Arnold & Co., 41–43 Maddox St., London, W. I. Imported by Longmans, Green & Co., 55 Fifth Ave., New York. $6.00.

This volume by Major Hingston, the brilliant English field naturalist, author of "Problems of Instinct and Intelligence," "A Naturalist in the Guiana Forest," etc., sets up an explanation of color and adornment which appears to bring the ramifications of the problem together into a more coherent theory than has been done by previous philosophers and students of these baffling lines of biological thought. The theory states (page 369), "(1) that there is a colour-conflict in animal pattern, (2) that this colour-conflict is the expression of a fear-anger conflict, (3) that animals are striving to develop in the direction of expressing their hostile impulses." The "fear" element of coloration in any animal is the concealing coloration of previous writers. The "anger" element of coloration in any animal is the warning coloration of previous writers, male sexual adornments, etc. He lines up male sexual ornamentation as an "anger" pattern by considering the attitude of male toward female as one of attack. This becomes a modified emotion of anger. The unfortunate teleological expression in three (3) above that "animals are striving to develop" has implications that will annoy many american students.

The chapter headings run as follows: Chapter 1, Explanation of the theory; 2–4, Mammals; 5, Birds; 6, Reptiles; 7, Insects; 8, General matters; 9, The meaning of extravagant weapons; 10, The meaning of song; 11, Mating flights and dances; 12, The meaning of moult; 13, The meaning of sexual dimorphism; 14, The meaning of courtship behaviour, and 15, The formation of geographical varieties. Index.

Many points in this theory are open to criticism. The problem appears to the reviewer to have a more complex foundation of conflicting physiological conditions than appears to be assumed by Hingston. For instance, Chapter 9, "The meaning of extravagant weapons." We feel that Julian Huxley's recent studies of these in his book on "The Problems of Relative Growth," give a more satisfactory explanation. We feel that the author should have given some space to the more basic aspects of color and form, those aspects of color and form as mere physiological products, which later have been manipulated by evolution into advantageous adaptations to the environment. Hingston deals with highly specialized forms, but biological problems are more often solved by the approach through lower, more generalized types where factors are fewer in number and the problems are of a simpler nature.

The reviewer believes that this volume is an outstanding addition to the theory of evolution; it has brought opposing things together and has handled them as two forces balanced against each other. The chapter on insects ties the marvelous and astounding colors and forms of insects into the general theory and will be of especial interest to entomologists.

It is refreshing to find a field naturalist with the wide experience of Major Hingston tackling these problems of theory in such a comprehensive manner. We sometimes feel that too many of our recent studies of behavior and adaptation have been done in the laboratory on animals injured and ill at ease in their imprisonment in our elaborate and expensive experimental cabinets. Such experimentation under controlled conditions should certainly be checked thoroughly by field observations.—C. H. K.